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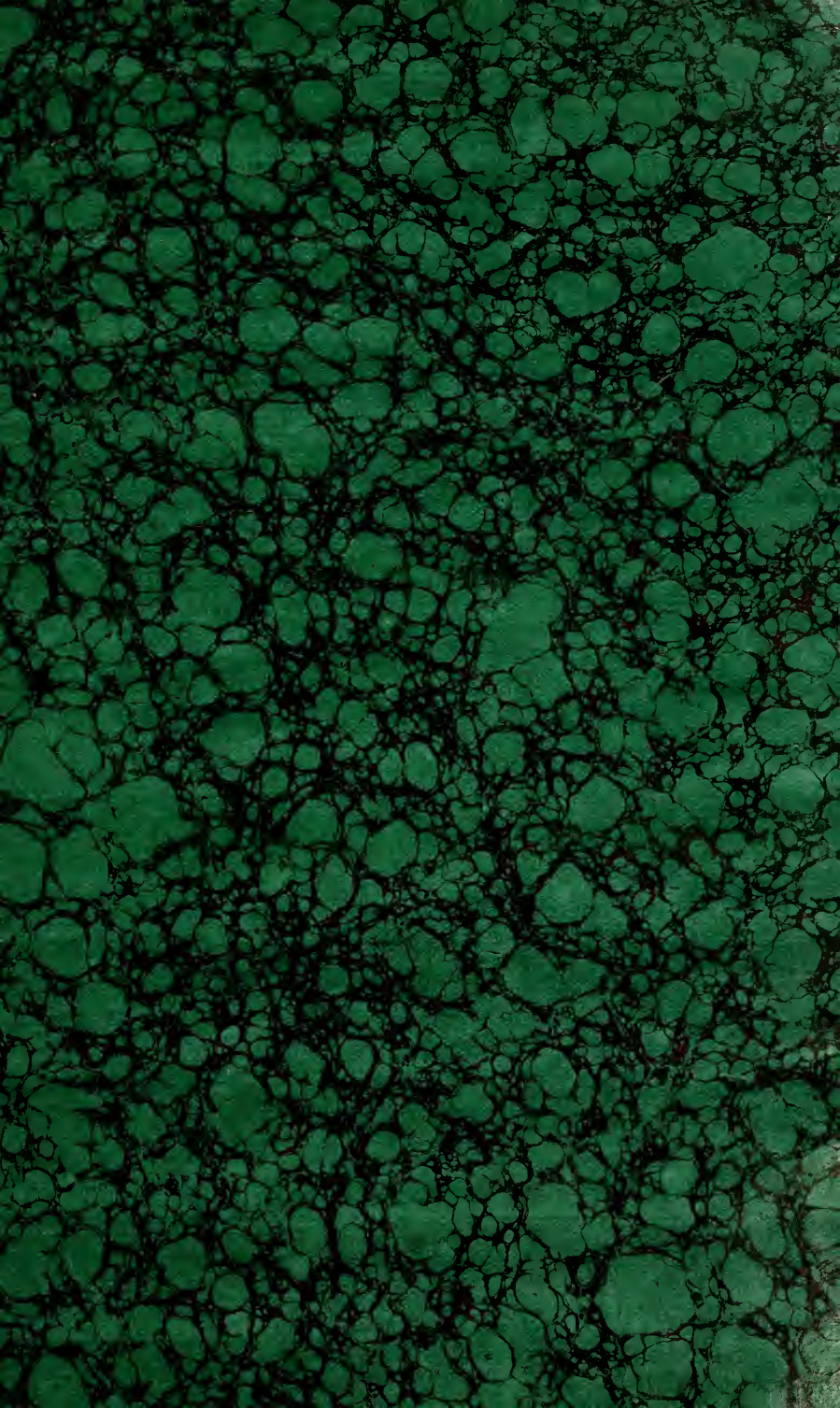
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November 1, 1901.



THE
CANADIAN NATURALIST
AND GEOLOGIST:

A Bi-Monthly Journal of Natural Science,

CONDUCTED BY A COMMITTEE OF THE NATURAL
HISTORY SOCIETY OF MONTREAL.

NEW SERIES.—Vol. II.

(WITH A PLATE.)

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MONTREAL:
DAWSON BROTHERS, GREAT ST. JAMES STREET.
1865.

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CONTENTS.

	PAGE
Contributions to the Chemistry of Natural Waters ; By T. STERRY HUNT, A.M., F.R.S.....	1, 161, 276
On the Relative Powers of Glaciers and Floating Icebergs in Modifying the Surface of the Earth ; By Sir RODERICK I. MURCHISON..	21
Origin of our Kitchen-Garden Plants ; By H. COULTAS.....	33
On the Graptolites of the Quebec Group ; By Professor JAMES HALL..	42
A few Notes on the Night-Heron ; By HENRY G. VENNOR.....	53
Notes on Post-Pliocene Deposits at Rivière-du-Loup and Tadoussac ; By J. W. DAWSON, LL.D., F.R.S.....	81
On the Genus Woodsia ; By Professor DANIEL C. EATON.....	89
On the Occurrence of Organic Remains in the Laurentian Rocks of Canada ; By Sir W. E. Logan, LL.D., F.R.S.....	92
On Certain Organic Remains in the Laurentian Limestones of Canada ; By J. W. DAWSON, LL.D., F.R.S.....	99, 127
Notes on the Structure and Affinities of Eozoön Canadense ; By W. B. Carpenter, M.D., F.R.S., F.G.S.....	111
On the Mineralogy of Eozoön Canadense ; By T. STERRY HUNT.....	120
Notes on Nova-Scotian Fishes ; By J. Matthew Jones, F.L.S.....	128
Notes on Some of the More Remarkable Genera of Silurian and Devonian Fossils ; By E. BILLINGS, F.G.S.....	184, 405
Gold Mines and Gold Mining in Nova Scotia ; By H. F. PERLEY....	198
On the Extraction of Copper from its Ores in the Humid Way ; By THOMAS MACFARLANE.....	219, 241
Synopsis of the Fishes of the Gulf of St. Lawrence and Bay of Fundy ; By Professor THEODORE GILL, M.A.....	244
Geological Sketch of the Neighborhood of Rossie ; By THOMAS MACFARLANE.....	267
A Geographical Sketch of Canada.....	356
Review of the Northern Buccinums, and Remarks on some other Northern Marine Mollusks. Part I. By Dr. WM. STIMPSON....	364
A Provisional Catalogue of Canadian Cryptogams.....	390
Notes on the Meeting of British Association.....	409
Notice of some New Genera and Species of Palæozoic Fossils. By E. Billings, F.G.S.....	425
The Natural History of the Sanguinaria Canadensis. By George D. Gibb, M.A., M.D., LL.D., F.G.S.....	432
Observations on the Drift Phenomena of Labrador. By A. S. Packard, jr., M.D.....	441

NATURAL HISTORY SOCIETY.

PAGE

Monthly Meetings.....	73, 77, 299, 310
Annual Conversazione...	75
Annual Meeting.....	300
The President's Address.....	300
Report of the Council.....	304
Report of the Scientific Curator	306
Officers for 1865-1866.....	308
The Canadian Naturalist.....	309
Treasurer's Report	311
J. F. Whiteaves on the Fossils of the Trenton Limestone.....	312

BRITISH ASSOCIATION.

Across the Rocky Mountains.....	65
President's Address; By John Phillips, M.A., LL.D.....	321
Address to the Geological Section.....	150
Report of the Committee for Exploring Kent's Cavern.....	445
Palæozoic Floras in Eastern North America.....	452
Report on Luminous Meteors	454
Researches in the Lingula Flags in South Wales.....	456
Notes on the Structure of the Matterhorn.....	459

REVIEWS AND BOOK NOTICES.

Proceedings of the Portland Society of Natural History.....	70
Icones Muscorum, by Wm. S. Sullivant	72
Monogram of the Bats of North America; By H. Allen, M.D....	144
Flora of the British West Indian Islands.....	150
The Conservation of Force; By E. L. Youmans, M.D.....	152
Geology of New Brunswick... ..	232, 314
Catalogue of the Museum at Harvard College.....	471
Embryology of the Starfish, &c., by Mrs. and A. Agassiz.....	472

MISCELLANEOUS.

A New American Silkworm	239
Botanical Note	240
Verrill on the Preservation of Starfishes.....	473
Harvard University Herbarium	473

ENTOMOLOGICAL SOCIETY.

Annual Meeting of Quebec Branch.....	57
Descriptions of New Species of Canadian Coleoptera.....	60
Description of a new Species of Alypia.....	64, 460
Canadian Insect Architecture. By W. Couper, Quebec.....	461

OBITUARY NOTICES.

Captain James N. Gilliss, U.S.N.....	135
George P. Bond.....	136
Hugh Falconer, M.D.....	137
Sir William Hooker.....	465
Dr. John Lindley.....	468

THE
CANADIAN NATURALIST.

SECOND SERIES.

CONTRIBUTIONS TO THE CHEMISTRY OF
NATURAL WATERS.

By T. STERRY HUNT, A.M., F.R.S.; of the Geol. Survey of Canada.

It is proposed to divide this essay into three parts, in the first of which will be considered some general principles which must form the basis of a correct chemical history of natural waters. The second part will embrace a series of chemical analyses of mineral waters from the paleozoic rocks of the Champlain and St. Lawrence basins, together with some river-waters; and the third part will consist chiefly of deductions and generalizations from these analyses.

I.

CONTENTS OF SECTIONS.—1, atmospheric waters; 2, 3, results of vegetable decay; 4-7, action on rocky sediments; 8, action on iron-oxyd; 9, solution of alumina; 10, reduction of sulphates; 11, kaolinization; 12, decay of silicates; 13, origin of carbonate of soda; 14, Bischof's view rejected; 15, 16, porosity of rocks, and their contained saline waters; 17, saliferous strata; 18, action of carbonate of soda on saline waters; 19, origin of sulphate of magnesia; 20, 21, Mitscherlich's view rejected; 22, 23, salts from evaporating sea-water, composition of ancient seas, origin of carbonate of lime; 24-27, origin of gypsum, carbonate of magnesia, and dolomite; 28, waters from oxydized sulphurets; 29, origin of free sulphuric and hydrochloric acids; 30, of hydrosulphuric and boric acids; 31, of carbonic acid gas; 32, of ammoniacal salts; 33-35, classification of mineral waters.

§ 1. The solvent powers of water are such that this liquid is never met with in nature in a perfectly pure state: even

meteoric waters hold in solution, besides nitrogen, oxygen, carbonic acid, ammonia, and nitrous compounds, small quantities of solid matters which were previously suspended in the form of dust in the atmosphere. After falling to the earth, these same waters become still farther impregnated with foreign elements of very variable nature, according to the conditions of the surface on which they fall.

§ 2. Atmospheric waters coming in contact with decaying vegetable matters at the earth's surface, take from them two classes of soluble ingredients, organic and inorganic. The waters of many streams and rivers are colored brown with dissolved organic matter, and yield, when evaporated to dryness, colored residues, which carbonize by heat. This organic substance, in some cases at least, is azotized, and similar, if not identical, in composition and properties with the apocrenic acid of Berzelius. The decaying vegetation, at the same time that it yields a portion of its organic matter in a soluble form, parts with the mineral or cinereal elements which it had removed from the soil during life. The salts of potassium, calcium, and magnesium, the silica and phosphates, which are so essential to the growing plant, are liberated during the process of decay; and hence we find these elements almost wanting in peat and coal. See on this point the analyses by Vohl of peat, peat-moss, and the soluble matters set free during its decay. *Ann. der Chem. und Pharm.*, cix, 185, cited in *Rep. Chim. Appliquée*, i, 289. Also Liebig, analysis of bog-water; *Letters on Modern Agriculture*, p. 44; and in the second part of this paper the analysis of the waters of the Ottawa river.

§ 3. At the same time an important change is effected in the gaseous contents of the atmospheric waters. The oxygen which they hold in solution is absorbed by the decaying organic matter, and replaced by carbonic acid; while any nitrates or nitrites which may be present are by the same means reduced to the state of ammonia (Kuhlmann). By thus losing oxygen, and taking up a readily oxydizable organic matter, these waters become reducing instead of oxydizing media in their farther progress.

§ 4. We have thus far considered the precipitated atmospheric waters as remaining at the earth's surface; but a great portion of them, sooner or later in their course, come upon permeable strata, by which they are absorbed, and in their subterranean circulation undergo important changes. The effect of ordinary argillaceous

strata destitute of neutral soluble salts may be first examined. Between such sedimentary strata and the waters charged with organic and mineral matters from decaying vegetation, there are important reactions. The composition of these waters is peculiar. They contain, relatively to the sodium, a large amount of potassium salts, besides notable quantities of silica and phosphates, in addition to the dissolved organic matters and the earthy carbonates, and in some cases ammoniacal salts and nitrates or nitrites. The sulphuric acid and chlorine are moreover not sufficient to neutralize the alkalies, which are perhaps in part combined with silica or with an organic acid.

§ 5. The experiments of Way, Voelcker, and others have shown that when such waters are brought into contact with argillaceous sediments, they part with their potash, ammonia, silica, and phosphoric acid and organic matter, which remain in combination with the soil; while, under ordinary conditions at least, neither soda, lime, magnesia, sulphuric acid, nor chlorine are retained. This power of the soil appears from the experiments of Eichhorn to be in part due to the action of hydrated double aluminous silicates; and the process is one of double exchange, an equivalent of lime or soda being given up for the potash and ammonia retained. The phosphates are probably retained in combination with alumina or peroxyd of iron; and the silica and organic matters also enter into insoluble combinations. It follows from these reactions that the surface-waters charged with the products of vegetable decay, after having been brought in contact with argillaceous sediments, retain little else than sulphates, chlorids, or carbonates of soda, lime, and magnesia. In this way the mineral matters required for the growth of plants, and by them removed from the soil, are again restored to it; and from this reaction results the small proportion of potash salts in the waters of ordinary springs and wells as compared with river-waters. From the waters of rivers, lakes, and seas, aquatic plants again take up the dissolved potash, phosphates, and silica; and the subsequent decay of these plants in contact with the ooze of the bottom, or on the shores, again restores these elements to the earth. See a remarkable essay by Forchhammer on the composition of fucoids, and their geological relations, *Jour. fur Prakt. Chem.*, xxxvi, 388.

§ 6. The observations of Eichhorn upon the reaction between solutions of chlorids and pulverized chabazite, which, as a hydrated

silicate of alumina and lime, may perhaps be taken as a representative of the hydrous double silicates in the soil, show that these substitutions of protoxyd bases are neither complete nor absolute. It would appear, on the contrary, that there takes place a partial exchange or a partition of bases according to their respective affinities. Thus the normal chabazite, in presence of a solution of chlorid of sodium exchanges a large portion of its lime for soda; but if the resulting soda-compound be placed in a solution of chlorid of calcium, an inverse substitution takes place, and a portion of lime enters again into the silicate, replacing an equivalent of soda; while, by the action of a solution of chlorid of potassium, both lime and soda are, to a large extent, replaced by potash. In like manner, chabazite, in which, by the action of a solution of sal-ammoniac, a part of the lime has been replaced by ammonia, will give up a portion of the ammonia, not only to solutions of chlorids of potassium and sodium, but even to chlorid of calcium. It results from these mutual decompositions that there is a point where a chabazite containing both lime and soda, or lime and ammonia, would remain unchanged in mixed solutions of the corresponding chlorids, the affinities of the rival bases being balanced.* Inasmuch, however, as the proportions of ammonia and potash in natural waters are usually small when compared with the amounts of lime and soda existing in the form of hydro-silicates in the soil, the result of these affinities is an almost complete elimination of the ammonia and potash from infiltrating waters.

§ 7. That the replacement of one base by another in this way is not complete is shown moreover by the experiments of Liebig, Dehérain and others, who have observed that a solution of gypsum removes from soils a certain amount of potash-salt, which was insoluble in pure water. In this way gypseous waters may also acquire portions of sulphate of soda, and perhaps of sulphate of magnesia, from silicates.

It is not certain that all the above reactions observed for chabazite are applicable without modification to the double hydro-aluminous silicates of sedimentary strata. Were such the case, important changes might, in certain conditions, be effected in the composition of saline waters. Thus in presence of a great amount of a hydrous silicate of lime and alumina, solutions of chlorid of

* Silliman's Journal [2] xxviii, 72.

sodium might acquire a considerable amount of chlorid of calcium; but it is probable that these reactions, however important they may be in relation to the soil, and to surface-waters with their feeble saline impregnation, have at present but little influence on the composition of the stronger saline waters. It is however not impossible that the action of the ancient sea-waters, holding a large amount of chlorid of calcium, upon the hydrated and half-decomposed feldspars which constituted the clays of the period, may have given rise to those double silicates which formed the lime-soda feldspars so abundant in the Labrador series.

§ 8. The reactions just described assume an importance in the case of waters impregnated with soluble matters from vegetable decay; and in this event, another and not less important class of phenomena intervenes, which are due to the deoxydizing power of the dissolved organic matter. By the action of this upon the insoluble peroxyd of iron set free from the decomposition of ferruginous minerals and disseminated in the sediments, protoxyd of iron is formed, which is soluble both in carbonic acid, and in the excess of the organic (acid) matter. By this means not only are great quantities of iron dissolved, but masses of sediments are sometimes entirely deprived of iron-oxyd, and thus beds of white clay and sand are formed. The waters thus charged with proto-salts of iron absorb oxygen when exposed to the air, and then deposit the metal as hydrated peroxyd, which when the organic matter is in excess, carries down a greater or less proportion of it in combination. Such organic matters are rarely absent from limonite, and in some specimens of ochre amount to as much as fifteen per cent.* The conditions under which hydrous peroxyd of manganese is often found are very similar to those of hydrous peroxyd of iron, with which it is so frequently associated; and there is little doubt that oxyd of manganese may be dissolved by a process like that just pointed out. A portion of manganese has been observed in the soluble matters from decaying peat-moss; and it seems to be generally present in small quantities with iron in surface-waters.

§ 9. There is reason to believe that alumina is also, under certain conditions, dissolved by waters holding organic acids. The existence of pigotite, a native compound of alumina with an organic acid, and the occasional association of gibbsite with limonite, point to such a reaction. That it is not more abundant in

* Geology of Canada, p. 512.

solution, is due to the fact, that, unlike most other metallic oxyds, alumina, instead of being separated in a free state by the slow decomposition of its silicious compounds, remains in combination with silica. The formation of bauxite, a mixture of hydrate of alumina with variable proportions of hydrous peroxyd of iron, which forms extensive beds in the tertiary sediments of the great Mediterranean basin, indicates a solution of alumina on a grand scale, and perhaps owes its origin to the decomposition of solutions of native alum by alkaline or earthy carbonates. Emery, a crystalline anhydrous form of alumina, has doubtless been formed in a similar manner. Silliman's Journal [2] xxxii, 287. The existence in many localities of an insoluble sub-sulphate of alumina, websterite, in layers and concretionary masses in tertiary clays, evidently points to such a process. Compounds consisting chiefly of hydrated alumina, are frequently found in fissures of the chalk in England. On the absence of free hydrated alumina from soils, see Müller, cited in Silliman's Journal [2] xxxv, 292.

§ 10. The organic matter dissolved by the surface-waters serves to reduce to the condition of sulphurets the various soluble sulphates which it takes up at the same time or meets with in its course. These sulphurets, decomposed by carbonic acid, which is in part derived from the atmosphere, and in part from the oxydation of the carbon of the organic matter, give rise to alkaline and earthy carbonates on the one hand, and to sulphuretted hydrogen on the other. In this way, under the influence of a somewhat elevated temperature, are generated sulphurous waters, whether of subterranean springs, or of tropical sea-marshes and lagoons. The reaction between the sulphurets thus formed and the salts or oxyds of iron, copper, and similar metals which may be present, gives rise to metallic sulphurets. The decomposition of sulphuretted hydrogen by the oxygen of the air, produces native sulphur; with which are generally found associated sulphates of lime and strontia. By virtue of these reactions, soluble sulphates of lime and magnesia may be completely eliminated from waters, the bases as insoluble carbonates, and the sulphur as sulphuretted hydrogen, free sulphur, or a metallic sulphuret. Moreover, as Forchhammer has pointed out in the paper already cited, sulphuret of potassium in the presence of ferruginous clays is also completely separated from solution, the sulphur as sulphuret of iron, and the alkali as a double aluminous silicate.

§ 11. We have thus far considered the composition of surface-

waters as modified by the decay of vegetation, or by the reactions between the matters derived from this source and the permeated sediments. Not less important however than the elements thus removed by substitution from sedimentary strata are those which are liberated by the slow decomposition of the minerals composing these sediments.

It has long been known that in the transformation of a feldspar into kaolin, the double silicate of alumina and alkali takes up a portion of water, and is resolved into a hydrous silicate of alumina; while the alkali, together with a definite portion of silica, is separated in a soluble state. The feldspar, an anhydrous double salt formed at an elevated temperature, has a tendency under certain conditions to combine at a lower temperature with a portion of water, and break up into two simpler silicates. Daubrée has moreover shown that when kaolin is exposed to a heat of 400° C. in presence of a soluble silicate of potash, the two silicates unite and regenerate feldspar. These reactions are completely analogous to those presented by very many other double salts, ethers, amides, and similar compounds. The preliminary conditions of this conversion of feldspar into kaolin and a soluble alkaline silicate, however, still require investigation. It is known that while some feldspathic rocks appear almost unalterable, others containing the same species of feldspar are found converted to a depth of many feet from the surface into kaolin. This chemical alteration, according to Fournet, is always preceded by a mechanical change of the feldspar, which first becomes opaque and friable, and is thus rendered permeable to water. He conceives this alteration to be molecular, and to be connected with the passage of the silicate into a dimorphous or allotropic condition.*

§ 12. The researches of Ebelman on the alterations of various rocks and minerals have thrown considerable light on the relations of sediments and natural waters.† From the analyses of basaltic and similar rocks, which include silicates of lime, magnesia, iron, and manganese in the forms of pyroxene, hornblende, and olivine, and which undergo a slow and superficial decomposition under atmospheric influences, it appears that during the process of decay the greater part of the lime and magnesia is removed, together with a large proportion of silica. It was found moreover that in the case

* *Annales de Chimie* [2] lv. 225.

† Ebelman, *Recueil des Travaux*, ii, 1-79.

of a rock apparently composed of labradorite and pyroxene, the removal of the lime and magnesia from the decomposed portion was much more complete than that of the alkalies; showing thus the comparatively greater stability of the feldspathic element. The decomposition of the feldspar in these mixed rocks is however at length effected, and the final result approximates to a hydrous silicate of alumina, or clay. This slow decomposition of silicates of protoxyd-bases appears to be due to the action of carbonic acid, which removing the lime and magnesia as carbonates, liberates the silica in a soluble form; while the iron and manganese passing to a state of higher oxydation, remain behind, unless the action of organic matters intervenes to give them solubility.

§ 13. It is to be remarked that apart from the peculiar and complete decomposition resulting in the production of kaolin, to which orthoclase, oligoclase, and some other feldspathides, as leucite, beryl, and perhaps also the scapolites and albite, are occasionally subject, orthoclase is less liable to change than the soda-feldspars, albite, oligoclase, and labradorite. Weathered surfaces of these become covered with a thin, soft, white, and opaque crust from decomposition, while the surfaces of orthoclase under similar conditions still preserve their hardness and translucency. The decomposition of feldspathides, and other aluminous double silicates, whether rapid and complete, or slow and partial, apparently yields the same results. A gradual process of this kind is constantly going on in the feldspathic matters which form a large proportion of the mechanical sediments of all formations; and in deeply buried strata is not improbably accelerated by the elevation of temperature. The soluble alkaline silicate resulting from this process is in most cases decomposed by carbonates of lime and magnesia in the sediments, giving rise to silicates of these bases (which are for the greater part separated in an insoluble state), and to carbonate of soda. Only in rare cases does potash appear in large proportion among the soluble salts thus liberated from sediments, partly because soda-feldspars are more subject to change, and partly from the fact that potash-salts would be separated from the percolating waters in virtue of the reactions mentioned in § 5. Hence it happens that apart from the neutral soda-salts of extraneous origin, waters permeating sediments containing alkaliferous silicates, generally bring to the surface little more than soda combined with carbonic and sometimes with boric acid, and carbonates of lime and magnesia with small portions of silica.

§ 14. This explanation of the decomposition of alkaliferous silicates and of the origin of carbonate of soda is opposed to the view of Bischof, who conceives that carbonic acid is the chief agent in decomposing feldspathic minerals.* The solvent action of waters charged with carbonic acid is undoubted, as shown by various experimenters, especially by the Messrs. Rogers,† but this acid is not always present in the quantities required. The proportion of it in atmospheric waters is so inadequate that it becomes necessary to suppose some subterranean source of the gas, which is by no means a constant accompaniment of natron-springs. A copious evolution of carbonic acid is observed in the vicinity of the lake of Laach, where the alkaline waters studied by Bischof occur.‡ The same thing is met with in many other localities of such springs, among which may be mentioned the region around Saratoga, where saline waters containing carbonate of soda, and highly charged with carbonic acid, rise in abundance from the Lower Silurian strata; but further northward, along the valleys of Lake Champlain and the St. Lawrence, similar alkaline-saline waters, which abound in the continuation of the same geological formations, are not at all acidulous. From this the conclusion seems justifiable that the production of carbonate of soda is a process, in some cases at least, independent of the presence of free carbonic acid. In this connection, it is well to recall the solvent power of pure water on alkaliferous silicates, as shown more especially by Bunsen, and also by Damour, who found that distilled water at temperatures much below 212° takes up from silicates like palagonite and calcined mesotype, comparatively large amounts both of silica and alkalies. (Damour, *Ann. Chim. et Phys.* [3] xix, 481.)

§ 15. Another and an important source of mineral impregnation to waters exists in the soluble salts enclosed in sedimentary strata, both in the solid state and in aqueous solution, and for the most part of marine origin. In order to form some conception of the amount of saline matters which may be contained in a dissolved state in the rocky strata of the earth, we have made numerous experiments to determine the porosity of various rocks; some few of the results of which may here be noticed. Fragments of the rocks were dried at a heat of 150° to 200° F., in a current of

* Bischof, *Chem. Geol.* ii, 181. † Silliman's Journal [2] v, 401.

‡ Bischof, *Lehrbuch*, i, 357-363.

dry air until they ceased to lose weight. They were then soaked in distilled water, and kept under it for many hours beneath an exhausted receiver. When thus saturated, they were wiped from adhering water, and weighed; first in air to determine the augmentation of weight from absorption, and secondly, in water to give, by the loss in weight, the volume of the specimens. These data furnish the means of determining the volume of water absorbed, which is given below for 100.00 parts of different rocks from the paleozoic strata of the St. Lawrence basin.

Potsdam formation, (sandstone)	3 specimens..	2.26—2.71
“ “ “	3 “	..... 6.94—9.35
Calceiferous “ (crys. dolomite)	4 “	..... 1.89—2.53
“ “ “ “	2 “	..... 5.90—7.22
Chazy “ (argil. limestone)	4 “	..... 6.45—13.55
Trenton “ (grey crys. “)	4 “	..... 1.18—1.70
“ “ (black impalp. “)	2 “	..... 0.30—0.32
Utica “ (black shale)	3 “	..... 0.75—2.10
Hudson River “ (arenac. “).....		—7.94
Medina “ (argil. sandstone)	2 specimens..	8.37—10.06
Guelph “ (crys. dolomite)	3 “	.... 9.34—10.60
Niagara “ (impalp. “)	2 “	.... 9.69—10.92

The above data might be much more extended, but sufficient have been given to show the porosity of the principal paleozoic rocks of the basin.*

§ 16. If we take for the Potsdam sandstone the mean of the first three trials, giving 2.5 per cent for the volume of water which it is capable of holding in its pores, we find that a thickness of 100 feet of it would contain in every square mile, in round numbers, 70,000,000 cubic feet of water; an amount which would supply a cubic foot (over seven gallons) a minute for more than thirteen years. The observed thickness of the Potsdam sandstone in the district of Montreal, varies from 200 to 700 feet, and the mean of 500 feet may be taken. To this are to be added 300 feet for the Calceiferous formation, whose capacity for water may be taken, like the Potsdam sandstone, at 2.5 per cent. We have thus in each square mile of these formations, wherever they lie below the water-level, a volume of 490,000,000 cubic feet of water, equal to a supply of a cubic foot per minute for 106 years.

* A great many similar determinations will be found in a Report on Building Stones to the British House of Commons in 1839, by Barry, Delabeche, and Smith. See also Delesse, *Bul. Soc. Géol.* [2] xix, 64.

The capacity of the 800 feet of Chazy and Trenton limestones which succeed these lower formations, may be fairly taken at one half that of those just named. But it is unnecessary to multiply such calculations: enough has been said to show that these sedimentary strata include in their pores great quantities of water, which was originally that of the ocean of the paleozoic age. These strata throughout the great Silurian basin of the St. Lawrence, are now for the greater part beneath the sea-level; nor is there any good reason for supposing them to have ever been elevated much above their present horizon. Wells and borings sunk in various places in these rocks show them to be still filled with bitter saline waters; but in regions where these rocks are inclined and dislocated, surface-waters gradually replace these saline waters, which in a mixed and diluted state appear as mineral springs. These saline solutions, other things being equal, will be better preserved in limestones or argillaceous rocks than in the more porous and permeable sandstones.

§ 17. But besides the saline matters thus disseminated in a dissolved state in ordinary sedimentary rocks, there are great volumes of saliferous strata, properly so called, charged with the results of the evaporation of ancient sea-basins. These strata enclose not only gypsum and rock-salt, but in some regions large quantities of the double chlorid of potassium and magnesium, carnallite; and in others sulphate of soda, sulphate of magnesia, and complex sulphates like blödite and polyhallite. Besides these crystalline salts, the mother liquors containing the more soluble and uncrystallizable compounds, may also be supposed to impregnate, in some cases, the sediments of these saliferous formations. The conditions under which these various salts are deposited from sea-water, and their relations to the composition of the ocean in earlier geological periods, are reserved for consideration in § 22. Infiltrating waters remove from these saliferous strata their soluble ingredients; which, together with the ancient sea-waters of other sedimentary rocks, give rise to the various neutral saline waters; while the mingling of these in various proportions with the alkaline waters whose origin has been described in § 13, produces intermediate classes of waters of much interest.

§ 18. I have elsewhere described the results of a series of experiments on the mutual action of the waters of these two classes.* When a dilute solution of bicarbonate of soda is gradu-

* Silliman's Journal [2] xxviii, 170.

ally added to a solution which, like sea-water, contains besides chlorid of sodium, the chlorids and sulphates of calcium and magnesium, the greater part of the lime separates as carbonate, carrying down with it only from one to three hundredths of carbonate of magnesia; a portion of lime however remaining in solution as bicarbonate. When the chlorid of calcium is wholly decomposed, the magnesian salt is attacked in its turn, and there finally results a solution in which the whole of the earthy chlorids are replaced by chlorid of sodium. A farther addition of the solution of carbonate of soda gives them the character of alkaline-saline waters; which moreover contain abundance of earthy carbonates.

The substitution of neutral carbonate for bicarbonate of soda in the above experiment does not affect the result, except in causing a somewhat larger proportion of magnesia to be thrown down with the carbonate of lime. The resulting liquid still retains large quantities of earthy carbonates in solution.*

§ 19. In the saline waters just considered, chlorids generally predominate, the sulphates being small in amount, and often altogether wanting. Some exceptions to this are however met with; for apart from waters impregnated with gypsum, whose origin is readily understood, there are others in which sulphate of soda or sulphate of magnesia enter largely. The soda-salt may sometimes be formed by the reaction between solution of gypsum and natriferous silicates referred to in § 7, or by the decomposition of gypsum by solution of carbonate of soda; while in other cases its origin will probably be found in the natural deposits of sulphates, such as glauberite, thenardite, and glauber-salt, which occur in saliferous rocks. A similar origin is probable for many of those springs in which sulphate of magnesia predominates. This salt also effloresces abundantly in a nearly pure form upon certain limestones, and is in some cases due to the action of sulphates from decomposing pyrites upon magnesian carbonate or silicate. In by far the greater number of cases, however, its appearance is unconnected with any such process; and is, according to Mitscherlich, due to a reaction between dolomite and dissolved gypsum.

§ 20. In support of this view, it was found by the chemist just named that when a solution of sulphate of lime was made to filter for some time through pulverized magnesian limestone, it was decomposed with the formation of carbonate of lime and sulphate of

* Geol. Survey of Canada, Report 1853-56, p. 468.

magnesia. This reaction I have been unable to verify. A solution of gypsum in distilled water was made to percolate slowly through a column of several inches of finely powdered dolomite, and after ten filtrations, occupying as many days, no perceptible amount of sulphate of magnesia had been formed. Solutions of gypsum were then digested for many months with pulverized dolomite, and also with crystalline carbonate of magnesia, but with similar negative results; nor did the substitution of a solution of chlorid of calcium lead to the formation of any soluble magnesian salt. Solutions of gypsum were then impregnated with carbonic acid, and allowed to remain in contact with pulverized dolomite and with magnesite, as before, during six months of the warm season, when only inappreciable traces of magnesia were taken into solution. These experiments show that no decomposition of dissolved gypsum is effected by native carbonate of magnesia, or by the double carbonate of lime and magnesia, at ordinary temperature.

§ 21. I find however that hydrated carbonate of magnesia readily and completely decomposes a solution of gypsum when agitated with it, with formation of carbonate of lime and sulphate of magnesia; and the same result is produced with the native hydrate of magnesia when mingled with a solution of gypsum in presence of carbonic acid. Now there may be dolomites which contain an admixture of hydro-carbonate of magnesia, as there certainly are others which like predazzite, are penetrated with hydrate of magnesia. The reaction between solutions of gypsum and such magnesian limestones, (with the intervention, in the case of predazzite, of atmospheric carbonic acid,) would suffice to explain the results obtained by Mitscherlich, and the appearance in certain cases of sulphate of magnesia as an efflorescence on dolomites. In the experiments above described, the nearly pure crystalline dolomites from the Guelph and Niagara formations were made use of.

§ 22. When sea-water is exposed to spontaneous evaporation, the whole of the lime which it contains separates in the form of sulphate, gypsum being insoluble in a concentrated brine, and subsequently the greater portion of the chlorid of sodium crystallises out in a nearly pure state. The mother-liquor of specific gravity 1.24, having lost about four fifths of its chlorid of sodium, still contains a large proportion of sulphate of magnesia. If the evaporation is continued at the ordinary temperature, till a density of 1.32 is attained, about one half of the magnesian sulphate separates, mixed

with common salt; and by reducing the temperature to 6°C. , a large portion of pure sulphate of magnesia now crystallizes out. The farther evaporation of the remaining liquor by the heat of summer causes the potassium-salt to separate in the form of a hydrous double chlorid of potassium and magnesium, an artificial carnallite.*

By varying somewhat the conditions of temperature, the sulphate of magnesia and the chlorid of sodium of the mother-liquor undergo mutual decomposition, with the production of sulphate of soda and chlorid of magnesium. Hydrated sulphate of soda crystallizes out from such a mixed solution at 0°C. , and by reducing the temperature to -18°C. the greater part of the sulphates may be separated in this form from the mother-liquor of 1.24, previously diluted with one tenth of water; without which addition a mixture of hydrated chlorid of sodium would separate at the same time. If, on the other hand, the temperature of the mixed solution be raised above 50°C. , the sulphate of soda crystallizes out in the anhydrous form, as thenardite. By the spontaneous evaporation during the heats of summer of the mother-liquors of density 1.35, a double sulphate of potassium and magnesium separates. These reactions are taken advantage of on a great scale in Balard's process, as modified by Merle,† for extracting salts from sea-water.

§ 23. The results of the evaporation of sea-water would however be widely different if an excess of lime-salt were present. In this case the whole of the sulphates present would be deposited in the form of gypsum at an early stage of the evaporation, and the mother-liquor, after the separation of the greater part of the common salt, would contain little else than the chlorids of sodium, potassium, calcium, and magnesium.

* The hydrous double chlorid of potassium and magnesium (carnallite of H. Rose) occurs in large quantities in a stratum of clay overlying a great bed of rock-salt 100 feet thick, at Stassfurth in Prussia. It is associated with considerable quantities of sulphate of magnesia. According to Clemm, this sulphate of magnesia, to which the name of *kieserite* has been given, and which occurs also in Anhalt, contains but one equivalent of water, ($\text{MgO}, \text{SO}_3 + \text{HO}$). It is not more soluble than gypsum, and unlike the ordinary sulphate of magnesia, loses the whole of its acid at a red heat in a current of steam, the acid passing off undecomposed. This salt is found in such large quantities as to be of economic importance. (Bull, Soc. Chim. de Paris, 1864, p. 297.)

† See my paper in Silliman's Journal [2] xxv. 361; also Report of the Juries of the Exhibition of 1862, class ii, p. 48.

§ 24. A consideration of the conditions of the ocean in earlier geological periods will show that it must have contained a much larger quantity of lime-salts than at present. The alkaline carbonates, whose origin has been described in § 13, and which from the earliest times have been flowing into the sea, have gradually modified the composition of its waters, separating the lime as carbonate, and thus replacing the chlorid of calcium by chlorid of sodium, as I have long since pointed out.* This reaction has doubtless been the source of all the carbonate of lime in the earth's crust, if we except that derived from the decomposition of calcareous silicates. (§ 12). In this decomposition by carbonate of soda, as already described in § 18, it results from the incompatibility of chlorid of calcium with hydrous carbonate of magnesia, that the lime is first precipitated, with a little adhering carbonate of magnesia; and it is only when the chlorid of calcium is all decomposed that the magnesian chlorid is transformed into carbonate of magnesia. This latter reaction can consequently take place only in limited basins, or in portions cut off from the oceanic circulation.

§ 25. It follows from what has been said that the lime-salt may be eliminated from sea-water either as sulphate or as carbonate. In the latter case no concentration is required; while in the former the conditions are two,—a sufficient proportion of sulphates to convert the whole of the lime into gypsum, and such a degree of concentration of the water as to render this insoluble. These conditions meet in the evaporation of modern sea-water; but the evaporated sea-water of earlier periods, with its great predominance of lime-salts, would still contain large amounts of chlorid of calcium; the insolubility of gypsum in this case serving to eliminate all the sulphates from the mother-liquor. Evaporation alone would not suffice to remove the whole of the lime-salts from waters in which the calcium present was more than equivalent to the sulphuric acid; but the intervention of carbonate of soda would be required.

§ 26. In concentrated and evaporating waters freed from lime-salts by either of the reactions just mentioned, but still holding sulphate of magnesia, another process, which I have elsewhere described, may intervene.† The addition of a solution of bicarbon-

* Canadian Journal for 1858, p. 202; Silliman's Journal [2] xxv, 102, and *Comptes Rendus*, June 9, 1862, p. 1191.

† Silliman's Journal [2] xxviii, 174.

ate of lime to such a solution gives rise, by double decomposition, to sulphate of lime and bicarbonate of magnesia. The former being much the less soluble salt, especially in a strongly saline liquid, is deposited as gypsum; and subsequently the magnesian carbonate is precipitated in a hydrous form. The effect of this reaction is to eliminate from the sea-water both the sulphuric acid and the magnesia, without the permanent addition to it of any foreign element.

§ 27. Gypsum may thus be separated from sea-water by two distinct processes,—the one a reaction between sulphate of magnesia and chlorid of calcium, and the other between the same sulphate and carbonate of lime. The latter, involving a separation of bicarbonate of magnesia, can, as we have seen, only take place when the whole of the chlorid of calcium has been eliminated; and if we suppose the ancient ocean, unlike the present, to have contained more than an equivalent of lime for each equivalent of sulphuric acid, it is evident that a lake or basin of sea-water free from lime-salts could only have been produced by the intervention of carbonate of soda. The action of this must have eliminated the whole of the lime as carbonate, or at least have so far reduced the amount of this base that the sulphates present would be sufficient to separate the remainder by evaporation in the form of gypsum, and still leave in the mother-liquor a quantity of sulphate of magnesia for reaction with bicarbonate of lime.

The source of the magnesian carbonate, whose union, under certain conditions, with the carbonate of lime, gives rise to dolomite,* may thus be due either to the reaction just described between bicarbonate of lime and solutions holding sulphate of magnesia, or to the direct action of carbonate of soda upon waters containing magnesian salts; but in either case the previous elimination of the incompatible chlorid of calcium must be considered an indispensable preliminary to the production of the magnesian carbonate.

§ 28. To the three principal sources of mineral matters in mineral waters already enumerated, viz., decaying organic matters, decomposing silicates, and the soluble saline matters in rocks, a few other minor ones must be added. One of these is the oxydation of metallic sulphurets, chiefly iron pyrites, giving rise to sulphate of

* Silliman's Journal [2] xxviii, 180-186; and further, Geol. Survey of Canada, Report for 1859, 214-218.

iron, and more rarely to sulphates of copper, zinc, cobalt, and nickel; and by secondary reactions to sulphates of alumina, lime, magnesia, and alkalies. This process of oxydation is necessarily superficial and local, but the soluble sulphates thus formed have probably played a not unimportant part. (§ 9.)

§ 29. Besides these last, which contain chiefly neutral and acid salts, there is another class of waters characterized by the presence of free sulphuric or hydrochloric acid, or both together. These acid waters sometimes occur as products of volcanic action, during which both hydrochloric acid and sulphur are often evolved in large quantities. This latter element generally comes to the surface as sulphuretted hydrogen, which by the oxydation of the hydrogen may deposit its sulphur in craters and fissures. In other cases, as shown by Dumas, the sulphur and hydrogen may be slowly and simultaneously oxydized at a low temperature, giving rise directly to sulphuric acid. Not less frequent, however, is probably the direct conversion, by combustion, of the sulphuretted hydrogen into water and sulphurous acid, which afterwards absorbing oxygen from the air is converted into sulphuric acid.

§ 30. The source of the hydrochloric acid and the sulphur of volcanoes is probably the decomposition of chlorids and sulphates at high temperatures. It is known that for the decomposition of earthy chlorids, water and an elevated temperature are sufficient; and at a higher temperature, chlorid of sodium is readily decomposed in presence of silicious and aluminous minerals, with the intervention of water. Another agency which probably comes into play in volcanic phenomena is that of organic matters, which, reducing the sulphates to sulphurets, enable the sulphur to be subsequently disengaged as sulphuretted hydrogen by the operation of water, either with or without the intervention of carbonic acid or of silicious and argillaceous matters. Even in cases where this reducing action is excluded, the ignition of sulphates in contact with earthy matters must liberate the sulphuric acid as a mixture of sulphurous acid and oxygen; and these uniting in their distillation upward through the strata, may give rise to springs of sulphuric acid.* To reactions similar to those just noticed, involving borates like stassfurthite and hayesine, or boric silicates like tourmaline, etc., are to be ascribed the large amounts of boric acid which are sublimed in some volcanoes, or volatilized with the watery vapor of the Tuscan *suffioni*.

* See the note to § 22, on kieserite.

§ 31. The action of subterranean heat upon buried strata containing sulphates and chlorids is then sufficient to explain the appearance of hydrochloric and sulphurous acids and sulphur, even without the intervention of organic matters, which are, however, seldom or never wanting; whether as coal, lignite, bitumen, and pyro-schists, or in a more divided condition. The presence of hydrogen and of marsh-gas, as observed by Deville among volcanic products, is an evidence of this. The generation of marsh-gas is, however, in most cases clearly unconnected with volcanic action or subterranean heat.

To the decomposition of carbonates in buried strata by silicious matters, with the aid of heat, is to be ascribed the great amounts of carbonic acid gas which are in many places evolved from the earth, and, impregnating the infiltrating waters, give rise to acidulous springs. The principal sources of this gas in Europe are in regions adjoining volcanoes, either active or recently extinct; but their occurrence in the paleozoic strata of the United States, far remote from any evidence of volcanic phenomena other than slightly thermal springs, shows that an action too gentle or too deeply-seated to manifest itself in igneous eruptions, may evolve carbonic acid abundantly. The sulphuric acid springs of western New York and Canada, to be described further on, are not less remarkable illustrations of the same fact.

§ 32. The frequent presence of ammoniacal salts in volcanic exhalations is here worthy of notice, especially when considered in connection with the rarity of nitric and ammoniacal compounds in natural waters, except in some local conditions, as in the wells of cities, etc., where they are sometimes observed in comparatively large amounts. The explanation of this is evident; for although nitrates themselves are not directly removed from the water, they are, by the reducing action of organic matters, converted into ammonia, which is retained by the soil. In consequence of this affinity, the argillaceous strata, whether of the present period or of older formations, hold in a very fixed form a considerable quantity of nitrogen. This, from the slowness with which it is eliminated in the form of ammonia under the influence of alkaline solutions, probably exists as an ammoniacal silicate. (§ 6.) The action of acids, however, as well as alkalies, may be supposed to liberate it from its combination, and thus generate the ammoniacal salts which are such frequent accompaniments of volcanic phenomena. The numerous experiments of Delesse show that ammonia, or at least nitrogen capable of being evolved by

heat and alkalies in the form of ammonia, is present in the limestones, marls, argillites, and sandstones of former geological periods, in qualities scarcely inferior to those in similar deposits of modern times, amounting, for most of the ancient sedimentary strata, to from one to five thousands of nitrogen ;* from which it will be seen that the amount of this element thus retained in the rocky strata of the earth's crust is very great.†

§ 33. If we attempt a chemical classification of natural waters in accordance with the principles laid down in the preceding sections, they may be considered under the following heads:

- A. Atmospheric waters.
- B. Waters impregnated with the soluble products of vegetable decay.
- C. Waters impregnated with the salts from decomposing feldspathic rocks, and holding a portion of carbonate of soda as a characteristic ingredient.
- D. Waters holding neutral salts of sodium, calcium, or magnesium from strata where they existed as solid salts, or as impregnating brines.
- E. Waters holding chiefly sulphates from decomposing pyrites; copperas and alum waters.
- F. Waters holding free sulphuric or hydrochloric acid.

§ 34. The name of mineral waters is popularly applied only to such as contain sufficient foreign matters to give them a decided taste; and hence the waters of the divisions A and B, and many of the feebler ones of C and D, are excluded. Those of E and F have peculiar local sources; but those of C and D are often associated in adjacent geological formations, and their commingling in various proportions gives rise to mineral waters intermediate in composition. In accordance with these considerations, a classification of mineral waters for technical purposes was adopted by me in the *Geology of Canada*, p. 531, including only those of C, D, and F, which were arranged in six classes.

- I. Saline waters containing chlorid of sodium, often with large portions of chlorids of calcium and magnesium, with or

* *Ann. des Mines* [5], xviii, 151-523.

† For an exposition of the views put forward in the four preceding sections, see my paper in the *Canadian Journal* for 1858, p. 206.

without sulphates. The carbonates of lime and magnesia are either wanting, or present only in small quantities. These waters are generally bitter to the taste, and may be designated as brines or bitters.

- II. Saline waters which differ from the last in containing, besides the chlorids just mentioned, considerable quantities of carbonates of lime and magnesia. These waters generally contain much smaller proportions of earthy chlorids than the first class, and are hence less bitter to the taste.
- III. Saline waters which contain, besides chlorid of sodium and the carbonates of lime and magnesia, a portion of carbonate of soda.
- IV. Waters which differ from the last in containing but a small proportion of chlorid of sodium, and in which the carbonate of soda predominates. The waters of this class generally contain much less solid matter than the three previous classes, and have not a very marked taste until evaporated to a small volume, when they will be found, like the last, to be strongly alkaline.

Of these four classes, I corresponds to the division D, and IV to C, while II and III are regarded as resulting from the admixture of these in varying proportions. Sulphates are sometimes present in these waters, but never predominate; in their absence, salts of barium and strontium are often met with. The chlorids are generally, if not always, associated with bromids and iodids. Small quantities of potassium-salts are also present, while borates, phosphates, silicates, and small portions of iron, manganese, and alumina, are generally present. These various waters are occasionally sulphurous, and those of the last three classes may be impregnated with carbonic acid.

- V. The fifth class includes acid waters remarkable for containing a large proportion of free sulphuric acid, with sulphates of lime, magnesia, portions of iron, and alumina. These waters, which are characterized by their sour and styptic taste, generally contain some sulphuretted hydrogen.
- VI. The sixth class includes some neutral saline waters, in which the sulphates of lime, magnesia, and the alkalies predominate, chlorids being present only in small quantities. These waters, like the last, are often impregnated with sulphuretted hydrogen.

The above classification, although adopted originally for the convenient description of the mineral waters of Canada, will, it is thought, be found to embrace all known classes of natural waters, with the exception of those included under E, and of some waters from volcanic sources holding muriatic acid. These may constitute two additional classes. In the first three of the classes above described, chlorids predominate; in the fourth, carbonates; and in the fifth and sixth, sulphates. The waters of the first, second, and sixth classes are neutral; those of the third and fourth, alkaline; and those of the fifth, acid.

The results of the chemical analysis of various waters of these classes, it is proposed to give in the second part of this paper.—
From Silliman's American Journal of Science, No. 116, 1865.

ON THE RELATIVE POWERS OF GLACIERS AND FLOATING ICEBERGS

IN MODIFYING THE SURFACE OF THE EARTH.

By SIR RODERICK I. MURCHISON.

Before I enter on the consideration of the new theory of the power of moving ice, let us take a review of the progress recently made in pointing out the extent to which ancient glaciers and their moraines have ranged within or on the flanks of the Alps. In the northern portions of the chain these phenomena long ago attracted the attention of some admirable observers. Originating with Venetz and Charpentier, the true active powers of glaciers were defined by Rendu, Agassiz, and Forbes, and subsequently by other explorers. In short, no doubt any longer obtains, that such was the powerful agency of the grand ancient glaciers, that blocks of crystalline rock were transported by them from the central Alps of Mont Blanc to the slopes of the Jura Mountains. When, however, we begin to seek for satisfactory explanations of the method of transport of these huge erratics, geologists (who are only geographers of another order) entertained different opinions. For my own part, I have had strong doubts as to whether the great blocks derived from Mont Blanc, and which lie on the slopes of the Jura, were ever borne thither by a vast solid glacier which advanced from the Lake of Geneva over the Cantons of Vaud and Neuchâtel. Whilst fully believing in the great power of glaciers and their

agency, my opinion was that these blocks were rather transported to their present habitats on the Jura on ice-rafts, which were floated away in water to the N.N.W., when the great glaciers melted, and the low countries were flooded. I founded this opinion on the fact, that in examining the Canton de Vaud, and particularly the tracts near Lausanne and the north side of the lake of Geneva, I never could detect the trace of true moraines. In that detritus I saw merely accumulations of loose materials, which had all the aspect of having been accumulated under running waters. But, even granting to the land-glacialists their full demand, and supposing that a gigantic glacier was formerly spread out in fan-shape, as laid down by several geologists, and recently in the little map of Sir Charles Lyell, in his work on the Antiquity of Man, and that it became eventually of such enormous thickness as to have carried up the great blocks on its surface, to lodge them on the Jura Mountains; there is still in it nothing which supports the opinion, as indeed Sir Charles has himself observed,* that the deep cavity in which the lake lies was *excavated* by ice.

The geologists who first embraced the view of the transport of the huge blocks on the Jura by a solid glacier, were of opinion that the great depressions and irregularities of the surface which we now see between the Alps and the Jura, including the lakes of Geneva and Neufchatel, were so filled up with snow and ice, that the advancing glaciers travelled on them as bridges of ice, the foundations of which occupied the cavities.

Let us now turn to the south side of the Alps, where a long incline accounts for the enormous extension of glaciers into the plains of Italy. Thus, in examining the remains of the old glaciers which once advanced into the valley of the Po, MM. Martins and Gastaldi show us, that one of these bodies extended from Mount Tabor to Rivoli, a length of fifty miles; and, therefore, was longer than any existing glacier described on the flanks of the Himalayas; † whilst those to the south of the Lago di Garda are shown to have had a much greater length. Demonstrating, along with many other authors, how these old glaciers had striated and polished the hard rocks through or on which they had advanced, these authors also clearly pointed out how the course of the glaciers had been deflected, so as to take a new direction, when they met with the

* See 'Antiquity of Man,' p. 312.

† Bull. Soc. Geol. de France, 1850.

obstruction of any promontory of hard rock. Further, M. Martins, being well acquainted with Norway, indicated that, just as in that country, the face of each rock in a valley was rounded off, polished, and striated where it had been opposed to the advancing mass of ice, and that its opposite or downward face, over which the ice had cascaded or tumbled, was left in a rough state; thus exhibiting the worn or "stoss-seite," and lee, or protected side, of the Scandinavian geologists. The subsequent works of M. Gastaldi on the geology of Piedmont, in 1853 and in 1861, bring within well-defined limits the phenomena of old moraines and ancient drift, and prove that the débris carried over each gorge and valley has been derived from the rocks which specially encase such depressions. He also clearly demonstrated that in many of these cases the gigantic boulders which are piled together and present the character of a cataclysmal origin, can all be accounted for simply by the power of advancing ancient glaciers. In these works M. Gastaldi very properly distinguishes between the erratic blocks which were evidently parts of old terrestrial moraines, and those which, associated with tertiary strata, are found in deposits with marine shells—the larger erratics in the latter, as in the Superga, having been transported in masses of ice which floated on the then sea.

Various other Italian authors have occupied themselves with glacial phenomena (particularly Omboni, Villa, Stoppani, Cornalia, Paglia, Parolini, &c.); the conclusion at which they have all arrived is, that there existed an enormous extension of the moraines sent forth by the ancient Alpine glaciers into the great valley of the Po. Geographers who have not studied the phenomena may well indeed be surprised when they learn, that the hills to the south of the Lago di Garda, and extending by Pozzolengo and Solferino to Cavriano,* or the very ground where the great battles of the year 1859 were fought (the hill of Solferino being 656 English feet above the sea), are simply great moraines of blocks and gravel, produced by the advance of former glaciers which issued from the southern slopes of the Alps.

Combining these observations with others of his own on the lake of Annecy, M. Mortillet suggested in 1862 a new theory, in attributing to the descent of the glaciers a great excavating power.

* See Paglio, 'Sulle Colline del Terreno Erratico all' estremità meridionale del Lago di Garda' (with map).

Believing, with all those who have been named, as well as with the most eminent of the Swiss and French geologists, that the last great up-heavals and denudations of the Alps had produced the irregularities of their surface, he inferred that before the glacial period began, the *débris* derived from the wear and tear of the mountains by watery action had, to a great extent, choked up the valleys and filled the rock-basins. He further believed that, in the cold period which followed, great glaciers, descending with enormous power, forced all such *débris* out of the original rock-basins, and left them to be occupied by the present lakes. It is proper here to state that M. Gastaldi was right, as well as M. Mortillet, who followed him, in presuming that great deposits of old water-worn alluvium or loose drift were accumulated before the formation of glaciers, inasmuch as the oldest moraines are seen to repose in many places on the former. It will presently be shown that this fact contains within it the proof that the glaciers were not and are not in themselves excavating bodies.

Preceding M. Mortillet, however, in reasoning upon the excavating power of former glaciers, my eminent associate, Professor Ramsay, had broached a much bolder theory. In his essay entitled "The Old Glaciers of Switzerland and North Wales," published in 1859, and republished with additions in 1860, he expressed the opinion that the excavation of deep hollows in solid rocks was due to a weight of superincumbent ice pressing and grinding *downwards and outwards*, over high, flat, and sometimes broad water-sheds and table-lands, during that period of intense cold which produced the old glaciers.* In 1862 he went still further; and whilst M. Mortillet was communicating his views on the continent, Ramsay, wholly unconscious of what M. Mortillet was doing, read a memoir to the Geological Society of London, showing that all the cavities occupied by lakes in Switzerland and the North of Italy had been excavated originally by the action of glacier ice. Whatever, therefore, be the fate of this ingenious view, Professor Ramsay has our thanks for having excited much useful enquiry, and for having compelled old geologists like myself to reconsider our conclusions.

If the view of M. Mortillet has been met with objections, still more is the theory of Ramsay opposed, and particularly in foreign

*See 'Peaks, Passes,' &c., (Alpine Journal, 1859,) and 'The Old Glaciers of Switzerland and North Wales,' London, 1860, p. 110.

lands. In this country it has indeed met with the most vigorous opposition on the part of Dr. Falconer, as recorded in our proceedings: and even Sir Charles Lyell, the great advocate of the power of existing causes, has stoutly opposed this bold extension of a most powerful *vera causa*.* Having explored the Alps, at various intervals, for upwards of forty years, I long ago came to the conclusion that their chief cavities, vertical precipices, and subtending, deep, narrow gorges, were *originally* determined by movements and openings of the crust, whether arranged in anticlinal or synclinal lines, or not less frequently modified by great transversal or lateral breaks, at right angles to the longitudinal or main folds of elevation and depression. Explorations of other mountainous regions, in various parts of Europe, have strengthened this conviction. I rejoice, therefore, to find that those geologists of Switzerland, who justly stand at the head of their profession, Professor Studer and M. Escher von der Linth, have sustained, by numerous appeals to nature, the views I hold in common with the great majority of geologists. Those Swiss explorers, who have labored for many years in their native Alps, and have constructed admirable geological maps of them, must surely be well acquainted with the ruptures of the various rocks, the outlines of which they have sedulously followed. Now, they attribute most of those deep cavities in which the rivers and lakes occur, either to dislocations producing abrupt fissures, or to great foldings of the strata leaving openings upwards where the tension has been the greatest—openings which were enlarged by powerful denudations. Numerous geologists have recently expressed their concurrence in the generally adopted view, that the Alpine lakes occupy such orographic depressions; and by close researches, my accomplished friend, Mr. John Ball † has ably sustained this view, and has further shown how slight is the erosive power of a glacier even when issuing from its main source. No one of them in short, any more than Professor Studer and myself, doubts that the origin of these lakes is primarily due to other causes. Nor am I aware that any geologists of France and Germany, much as many of them have examined the Alps, have deviated from the opinion that the main diversity of outline in that chain was due to ruptures and denudations that occurred during the upheavals of the chain.

* See 'Antiquity of Man,' pp. 316 *et seq.*

† See 'Phil. Mag.' 1863.

On the other hand, I am bound to state that, although the new theory has met with little or no favor on the continent of Europe, it is supported by our able geologists, Jukes and Geikie. Again, whilst Ramsay extended his view to the great lakes of the Alps, the eminent physicist Tyndall speculated even upon all the Alpine valleys having been formed by the long processes of the melting of snows and the erosion of ice.* With every respect for the reasoning of my distinguished countryman, I rely upon my long acquaintance with the structure of the Alpine chain; and now that I see sound practical geologists, who have passed their lives in examining every recess of those mountains, rejecting this new theory, and pointing out in place of it, the proofs of ruptures and denudations in the chain, I adhere firmly to the view I have long entertained.†

Those who wish to analyze this matter, must consult the admirable essay of Professor Studer on the origin of the Swiss lakes.‡ They will find numerous proofs of the views sustained by the leader of Alpine geologists. He shows you, indeed, how many of the rivers now flow in fissures or deep chasms in very hard rocks of different composition; chasms which water alone could never have opened out, particularly in those cases where the river has left a softer rock, and, with very slight obstacles to its straight course, has availed itself of one of these deep transverse natural gorges, which have evidently been produced by a great former rent. My

* See Tyndall on the Conformation of the Alps, 'Phil. Mag.' vol. xiv, 1862, p. 169, and also Ramsay on the Excavations of the Alps, xvi, p. 377.

† Some remarkable facts have been mentioned to me in a letter by M. Escher von der Liuth, as proving the inapplicability of the ice-erosion theory to the Swiss lakes. 1st. That the glacier of Rosenlauri, which descends from a great altitude, does not enter a low deep narrow gorge of the valley, but forms a bridge over it; and so it is to be inferred, that as the ancient glacier did not excavate this gorge, still less did it excavate the great valley in which the present glacier is embosomed. Again: he points out that, as the bottoms of many of the Swiss lakes are below the level of the sea, the glacier which is supposed to have excavated the hollow would have had to ascend considerable heights to emerge from the depression which it had excavated—an impossible movement, and contradicted by the existing operations of all glaciers.

‡ 'Origine des Lacs Suisses,' Biblio. Univ. et Revue Suisse (Arch. des Sci. Phys. et Nat.) xix, liv. de Février, 1864; also Phil. Mag., vol. xxvii, p. 481.

personal observations in the Alps, Carpathians, and Ural mountains enable me to confirm this view. As regards the continent of Europe, I should transport you to the Rhine, the Danube, and other great streams, which, flowing through flat countries with little declivity, never could have eroded those deep, abrupt gorges through which they here and there flow, and which are manifestly due to original ruptures of the rocks.*

In holding these opinions as to the small power of watery or glacial action, when not acting on an adequate incline, I do not doubt that glaciers have been, and still are, most important agents in modifying the outlines of mountains. Their summits are, we know, continually degraded by rains and melted snows, and torrents flowing down from them and carrying much detritus, are, doubtless, deepening their channels wherever sufficient slopes occur. But to whatever extent this agency has been and is at work, and to however great a degree a descending glacier may scratch and round off the rocky bottom on which it advances, I coincide with Professor Studer, and with many other observers, that the amount of erosion produced by these icy masses, particularly when they have advanced into valleys where there is only a slight inclination, must be exceedingly small. In valleys with a very slight descent it will presently be shown that, even in the Alps, no erosion whatever takes place, particularly as the bottom of the glacier is usually separated from the subjacent rock or vegetable soil by water arising from the melting of the ice. Again, in all the steeper valleys down which ancient glaciers have formerly descended, we do not find that either the sides or bottoms of the upper gorges afford any proof of wide erosion, but only exhibit the peculiar fashioning of the flanking surfaces of the rocks, or that rounding off and polishing, called *moutonné*, accompanied with striations. On the contrary, in gorges whence the largest glaciers have advanced for ages, we meet with islands of solid rock and little bosses still standing out, even in the midst of valleys down which the icy stream has swept.

With such proofs before us of what the frozen rivers called glaciers have done and are doing in the high valleys, how can we

* The recent Russian exploration of Eastern Siberia has shown how the grand river Amur deflects suddenly at nearly right angles from its course in a comparatively low country, to take advantage of a deep natural rent in the mountains through which it escapes to the seaboard (see p. 201 of the present Address to the Royal Geographical Society).

imagine, as Dr. Falconer has forcibly put it, that the glacier which is supposed to have occupied the Lago Maggiore, for example, and had advanced its moraines into the plains of the Po, should have had the power to plough its way down to a depth of 2000 feet below the Mediterranean, and then to rise up along an incline at the rate of 180 feet per mile? Nor can I admit the possible application of this ice-excavating theory wherever I see that a depression in which a lake occurs is at right angles to the discharge of an old main glacier. This is remarkably to be noticed in the case of the Lake of Geneva, which trends from E. to W., whilst the detritus and blocks sent forth by the old glacier of the Rhone have all proceeded to the N. and N.N.W.; or in direct continuation of the line of march of the glacier which issued from the narrow gorge of the Rhone. By what momentum, then, was the glacier to be so deflected to the west that it could channel or scoop out, on flat ground, the great hollow now occupied by the Lake of Geneva? And, after effecting this wonderful operation, how was it to be propelled upwards from this cavity on the ascent, to great heights on the slopes of the Jura mountains?

Still stronger objections exist to the application of the excavation theory to the Lake of Constance. There I have never been able to see on the northern flank of the Hohe Sentis, which presents its abrupt, precipitous, and highly dislocated and contorted jurassic and cretaceous rocks to the lake, with terraces of miocene deposits, at various heights,—there I have been unable, when with my indefatigable friend and companion, M. Escher von der Linth, who knows every inch of the ground, to trace the signs of the action of a great glacier, which could, in its descent, have so plunged into the flat region on the east and north, as to have scooped out the cavity in which the Lake of Constance lies. In this case, indeed, there are no traces whatever of those great old moraines from the relics of which we infer that glaciers have formerly advanced; the level country to the north of the lake being entirely free from them.

Great orographic depressions and deep cavities, sometimes dry, sometimes filled with water, occur in numberless countries where no glaciers ever existed. Thus, in Spain, as my colleague, M. de Verneuil assures me, the large depressions on either side of the granite mountains of the Guadarramma present exactly the appearance which a theorist might attribute to excavation by ice, and yet, however these cavities were formed, it is certain that no glacier

has ever existed there. Nor, again, has ice ever acted on the sides of the steep mountains of Murcia, where deep excavations and denudations are seen upon the grandest Alpine scale.

If we transport ourselves from those southern climes to the northern latitudes of the Ural mountains, where doubtless ice and snow formerly prevailed to a greater extent than now, we do not there find any proof whatever of the action of glaciers; for the hills are much too low to have given propulsion to such masses. On the contrary, we know that great blocks of hard rocks have been transported to the foot of these hills from Lapland and Scandinavia, when, during the glacial period, a vast Arctic Sea watered the flanks of the Ural mountains, and when most parts of that low chain could then have been only slightly elevated above the waters. And yet on the sides of this chain, where no glaciers have ever so acted as to produce erosion, we meet with both longitudinal and transverse deep fissures in some of which lakes, and in others rivers, occur. Thus, all along the eastern flank of the Ural mountains we find a succession of depressions filled with water, without a trace, on the sides of the bare and hard rocks which subtend these lakes, of any former action of glaciers. Then, as to deep valleys in which rivers flow, let us take two out of the examples along the western flank of this chain, on which my companions De Verneuil and Keyserling, and myself, have specially dwelt in our work on Russia. The Serebrianka River, as it issues from a network of metamorphic schists, quartz-rocks, and marbles of Silurian age, exhibits on its rugged banks the extrusion of much igneous matter. This agency has split up the stratified deposits; and the necessarily accompanying movements have caused great openings, including the cavity in which the river flows. Or, when the geological traveller passes from the valley of the Serebrianka to that of its recipient, the Tchussovaya, still more is he struck with wonderment at the unquestionable evidences, amidst intensely dislocated rocks, of the ruptures by which the deep narrow chasm has been formed in hard crystalline rocks, in which a lazy stream flows, which, not descending from any altitude, has had no excavating power whatever, and, like our own meandering Wye, has flowed on through clefts in limestone during the whole historic and pre-historic period, without deepening its bed.*

* For a full description of the abrupt gorge of the Tchussovaya, see 'Russia and the Ural Mountains,' vol. i, p. 352 *et seq.*

But if rivers which are not torrential, and do not descend from heights, cannot possibly have produced, nor even have deepened, the natural hollows or chasms in which they flow, still it might be contended that, what water has not effected, may have been done by a river, when, in the compacter form of ice, it descended and advanced across the lower country. Unluckily for the supporters of the ice-excavating theory, the data which existing nature presents to us, as before said, are decisively opposed to their view. The examination of those tracts over which glaciers have advanced, and from which they have retreated, shows, in the most convincing manner, that ice has so much plasticity that it has always moulded itself upon the inequalities of hard rocks over which it passed, and, merely pushing on the loose detritus which it meets with, or carries along with it from the sides of the upper mountains, has never excavated the lateral valleys, nor even cleared out their old alluvia. This fact was well noticed by the Swiss naturalists, as evidenced by present operations, at their last meeting in the Upper Engadine, and has been well recorded by that experienced and sagacious observer of glacial phenomena, M. Martins.*

Since that time the able French geologist, M. Collomb, who was associated with Agassiz in his earliest researches on glaciers, and has been the companion, in Spain, of my colleague, M. de Verneuil, has recently put into my hands the results of his own observation upon the present and former agency of the glaciers of the Alps, which decisively show that ice, *per se*, neither has nor has had any excavating power.† None of the glaciers of the Alps cited by M. Collomb, viz., those of the Rhone, the Aar, the Valley of Chamounix, the Allée Blanche, and the valley of Zermatt, produce any excavation in the lower grounds over which they pass. That of Göerner, which, among others, is advancing, affects very slightly the surface of the meadows on which it proceeds, and does not penetrate into the soil. Again, where the glacier of the lower Aar pushes, on its front, upon accumulations of the débris of old moraines and gravel, it scarcely deranges these materials, but slides over them, leaving them covered with mud and sand, but not

* See 'Revue des Deux Mondes,' March, 1864. The former observations of M. Martins on Norway and on the Alps are of the highest importance.

† I may add that M. Collomb expresses that which I believe to be the opinion of Elie de Beaumont, d'Archiac, De Verneuil, Daubrée, and of all the leading French geologists.

excavating them. Also, the glacier of the Rhone, the principal part of which can be so conveniently studied, advances on a gravelly substratum, in which it does not form a channel. Such being the facts as regards glaciers now advancing, M. Collomb cites equally strong, if not still stronger, cases, in support of his view, as derived from the observation of retiring or shrinking glaciers in the valleys of the Alps. Examining last year with M. Daubrée the glaciers of the Valley of Chamounix, he was attracted to that named Bossons, which he had not seen for five years. During that time the glacier had shrunk very considerably, both in altitude and length, and yet upon the surface of the ground from which it had retired there was not the smallest sign of excavation.

Viewing a glacier as a plastic body, we know that it is pressed onwards by gravitation from the increasing and descending masses of snow and ice behind it in the loftier mountains, and, being forced to descend through narrow gorges, it naturally acts with the greater energy on the precipitous rocky flanks of these openings; striating and polishing them with the sand, blocks, and pebbles which it holds in its grasp. But, as before touched upon, the narrowness of many of those channels through which glaciers have been thrust for countless ages, is in itself a demonstration that the ice can have done very little in widening the gorge through which it has been forced, and where, of necessity, it exerted by far its greatest power. In other words, the flanking rocks of each gorge have proved infinitely more stubborn than the ice and its embedded stones, which have merely served as graters and polishers of the granites, quartz rocks, porphyries, slates, marbles, or other hard rocks, among which the frozen river has descended. And, if such has been the amount of influence of advancing glaciers in the higher regions, where the body descends with the greatest power, how are we to believe that when this creeping mass of ice arrived in low countries (as for instance in the depressions occupied by the Lakes of Geneva and Constance) it could have exerted a power infinitely greater than that which it possessed in the higher regions?

When we turn from modern glaciers to the remains of those of ancient date, the proofs are equally decisive, that, whatever might be their extent, those gigantic bodies exercised no excavating power. I am reminded by M. Collomb, as well as by M. Escher von der Linth, that in many parts of the Alps, vast old moraines repose directly on incoherent and loose materials of quaternary age; the old drift of the Alps containing *Elephas primigenius* and

Rhinoceros tichorhinus. Well may we then ask, how is it that the ancient and larger glaciers, which were supposed to have had such enormous excavating power as to have scooped out deep valleys in hard rocks, should not have entirely destroyed the loose accumulation of gravel over which they have been spread? Or, if glaciers excavated the Lago di Garda and Lago Maggoire, why did they not produce any such effect at Ivrea, in the Valley of Aosta, down which we know that enormous masses of ice travelled; or at Rivoli, in their march from Mount Cenis towards Turin?

Leaving it to physical philosophers, such as Forbes, Faraday, Hopkins, and Tyndall, to show what is the real measure of the abrading power of masses of moving ice, I simply form my opinion from what glaciers are accomplishing, or have accomplished. Judging from positive data, I infer that if, as agents, they have been wholly incapable of removing even the old and loose alluvial drift which encumbered the valleys, infinitely less had they the power of excavating hard rocks. At the same time I know that, in every mountain tract which I have examined, there have been quite a sufficient number of rents and denudations to account for all inequalities. These openings have doubtless been greatly increased by the atmospheric agencies of ages, and particularly in all those situations where water has acted with great power, during the melting of glaciers. * * * * *

Whilst I was reading this Address to the Geographers in London, that sound practical geologist, Principal Dawson, was performing a similar duty at the Annual Meeting of the Natural History Society of Montreal. Having received a copy of his Address in time for insertion of a Postscript, I am glad to have the opportunity of stating that he also is a vigorous opponent of the theory which refers the striation of the North American rocks, and the excavation of the great lake-basins of that country, to the action of terrestrial glaciers. He shows indeed that the great striation of a large portion of the continent from N. E. to S. W. was from the ocean to the interior, against the slope of the St. Lawrence valley, thus disposing at once of the glacier theory; for it is impossible to imagine that a glacier travelled from the Atlantic up into the interior. Admitting that in limited tracts of Eastern America there may have been local glaciers, Mr. Dawson believes, as I do, that the rocks of the chief countries in question were striated when the land lay beneath the sea.—*From his address as President at the Anniversary of the Royal Geographical Society, London, 1864.*

ORIGIN OF OUR KITCHEN-GARDEN PLANTS.

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For a long time it was thought to be impossible to discover the origin of those nutritive species of plants commonly cultivated by man; some writers maintaining that their primitive habitat had been destroyed, that they originated on lands over which the ocean now rolls its waters; whilst others, equally fanciful, supposed a miraculous intervention of the Deity, and that man received directly from the gods the first seeds of the cerealia and other plants, which he cultivates as sources of food. The prevailing opinion upon this great question, even among enlightened persons, and so late as the commencement of the present century, may be gathered from the following passage from Humboldt's *Essay upon the Geography of Plants* (*Essai sur la Géographie des Plantes*, 1807, p. 28):—

“The country in which originated the vegetables most useful to man is a secret as impenetrable as the first dwelling-place of our domestic animals. We are ignorant of the country in which the grasses first originated which furnished nutriment to the Mongolian and Caucasian races. We know not in what country our cerealia grow spontaneously—our wheat, oats, and rye. The plants which constitute the natural riches of the inhabitants of the tropics, the banana, papaw, cassava, and maize, have never yet been found in a wild state. The potato presents the same phenomena.”

Since the time when the above passage was written by this illustrious author, the wild potato has been found growing in the greatest abundance in South America; the papaw, by Marcgraaf, in the forests of Brazil; and Olivier and Bruguières, in travelling through Western Asia—the cradle of the European race—have found wild rye and barley. Thus year by year the progress of geographical and botanical researches conduces to more certain and simple ideas on the origin of cultivated plants, so that our best naturalists now, instead of supposing, as formerly, miraculous phenomena, or revolutions in the physical geography of the planetary surface, are all agreed that it is highly probable that all our cultivated plants have originally descended from some wild form;

and that probably some day, at no very distant period, we shall know in a spontaneous state the immense majority, perhaps the totality of our cultivated species.

M. Alphonse de Candolle gives a list of 157 plants, which he selects, because most commonly cultivated by man, and of these eighty-five have been found wild—that is to say, identical with the cultivated plant, or at least with some of its varieties. If to these species are added those which are most probably wild, or about which hardly a doubt remains, we may consider 117 as having been identified in a spontaneous state. In short, the species which we historically know to have been first cultivated in Europe, have been found wild in Europe; and those cultivated species of which the wild form has not yet been found, are all foreign plants cultivated abroad, and in countries which have not yet been explored.

Having made these introductory remarks, we now confine ourselves to an inquiry into the origin of the kitchen-garden plants of the United Kingdom. We select for this purpose such vegetables as are in ordinary use during winter; in fact, our common Christmas vegetables will furnish an abundance of interesting material for discussion.

Our kitchen-garden plants may be sub-divided into—1. Those plants which are cultivated for the nutritive material in their rhizome, as the potato, parsnip, carrot, turnip, and horseradish. 2. Those plants which are cultivated for their stems, leaves, and flowers, as celery and the different varieties of the garden cabbage. We begin with that well-known vegetable,

The POTATO (*Solanum tuberosum*, L.)—This plant belongs to the natural order Solanaceæ, and is closely related to the tobacco-plant, belladonna, henbane, nightshade, and other poisonous narcotics. But although the same poisonous principle exists in the potato-plant, it is confined to its stem, foliage, and fruit, and is wholly absent from its roots or underground tubers, the part of the plant used as food. When potatoes still attached to the growing plant become exposed to the light, the epidermis assumes a greenish color, and the poisonous principle then develops itself. Such potatoes are totally unfit for human food. The potato-plant has a stem from one and a half to two feet high, with interrupted pinnate leaves, which are composed of from five to seven pairs of lanceolate oval leaflets, having lesser ones between them; the flowers are bluish-white, with orange yellow, slightly cohering anthers, which are succeeded by a green globose berry, about half an inch

in diameter. The tubers or potatoes produced by the plant are simply subterranean branches, arrested and thickened in their growth, in place of being elongated. The common idea that all the subterranean portions of a plant are roots, is quite erroneous; for the production of leaf-buds or leaf-scars is the distinguishing characteristic of a stem wherever situated; and that the tuber or potato is a true stem is proved by the eyes on its surface, which are true leaf-buds. Hence the potato is propagated by cutting the tuber into pieces, when each piece, provided it has an eye, will grow and become an independent plant.

The potato is a native of South America, and is found in abundance wild in the mountainous regions of Chili, Peru, and the neighborhood of Buenos Ayres. Its presence in Mexico, Virginia, and the Carolinas, where it was subsequently found, is probably not very ancient. It is thought that it may have been introduced there from South America by the first Spanish settlers. The potato was first grown by Sir Walter Raleigh, at Youghal, in Ireland, in 1586. The samples planted came from the Carolinas. The gardener who planted the tubers thought that the green potato apples were the potatoes, and carried them to his master, expressing his great disgust at such produce. Sir Walter, pretending to sympathize, told him to dig up the useless weeds, and throw them away. The gardener, in rooting out the plants, found the true potatoes, more than a bushel of them, and hurried back to his master in a very different humor, to show him the samples, and make known his discovery.

The soil and climate of Ireland are very favorable to the growth of good potatoes, and the plant appears to have rapidly grown into favor in Ireland, and was cultivated there as food long before its value was acknowledged in Great Britain.

In both England and Scotland, a prejudice against it existed owing to the poisonous character of the plants of the natural order to which it belongs and the resemblance of its flowers to those of the woody nightshade (*Solanum dulcamara*), an extremely common plant, well known to be poisonous. Almost everywhere the same prejudice prevailed, in France especially; and it was not until a time of great scarcity during the Revolution, that its culture in that country became general.

For more than a century and a half after its cultivation by Sir Walter Raleigh in Ireland, the potato was cultivated in flower gardens only, in both England and Scotland. Even in 1725 the

few potato-plants in the gardens about Edinburgh were left in the same spot from year to year. No attempt was made at a more extended culture. In 1728, however, a Scotch day-laborer, named Thomas Prentice, living near Kilsyth, Stirlingshire, carefully cultivated the potato as food, and, after supplying the wants of his own family, sold the remainder of the produce to his neighbors, who very willingly paid him his own price, being convinced by his example that potatoes were wholesome and nutritious. Prentice was frugal and industrious, and soon found himself in possession of £200, no small fortune in those days. He now sank his capital in an annuity at a good interest, upon which he lived independently in his old age, dying in the year 1792, at the advanced age of eighty-six (potatoes evidently agreed with him), having been sixty-four years a happy witness to the effects of the blessing which he had been instrumental in conferring on his country.

The potato appears to have been taken into favor much earlier in England, as appears from a report of a meeting of the Ray Society, held March 18th, 1662, when a letter was read from Mr. Buckland, a Somersetshire gentleman, recommending the planting of potatoes. This was referred to a committee, who reported favorably, and Mr. Buckland received the thanks of the Society. From this time the field-culture of the potato commenced, and rapidly extended as its excellent qualities became more known. A strange objection was made by the Puritans, who denied the lawfulness of eating potatoes, because the plant was not mentioned in the Bible! Whether or no, a plant so nutritious, and whose culture is adapted to almost every soil and climate, must be regarded as amongst the choicest gifts of Providence. Our countrymen have since done ample justice to this plant; for now, wherever the Englishman seeks a home, he always strives to naturalize the potato-plant, and, even when surrounded by the luxuries of tropical lands, remembers the simple vegetable which was so long struggling into notice in his own country.

The PARSNIP (*Pastinaca sativa*, L.)—This plant belongs to the natural order Umbelliferae, and is closely related to the carrot, celery, and parsley, which belong to the same natural order. It is a native of Britain, and of different parts of Europe, and is usually most plentiful on dry banks or on a chalky soil. It is difficult to say whether it is to cultivation or importation that we are indebted for this root. Most likely the former, as it is undeniable that the wild plant, grown for two or three years in rich

garden soil, acquires all the characters of the cultivated form ; and that when the garden-plant escapes into uncultivated ground, it speedily reverts back to its originally wild and degenerate condition. Parsnips appear to have been very early reclaimed from a wild state, for Pliny tells us that parsnips were cultivated on the banks of the Rhine, and were brought from thence to supply the tables of the Roman emperors.

The stem of the parsnip is herbaceous, upright, and furrowed ; the leaves pinnate, sheathing the stem at the base, and composed of oval, slightly lobed and incised leaflets. The flowers are small, yellow, and disposed to umbels, the fruit dividing into two seed-like pieces, as is usual with umbelliferous plants. The root of the wild plant is spindle-shaped, sweet and mucilaginous, but nevertheless somewhat woody, and with a slight degree of acrimony which it loses by cultivation. In the wild plant the leaves are downy, but when cultivated they become smooth.

The parsnip is one of the hardest plants of the kitchen garden, as it remains uninjured in the severest weather ; indeed, by many, the parsnip is not esteemed until it has been frost-bitten. There is generally a great consumption of parsnips in Catholic countries along with the salt-fish eaten during lent.

The CARROT (*Daucus carota*, L.)—The wild form of this plant is found plentifully in Europe and in Great Britain, where it is indigenous, and in the United States where it has been extensively naturalized. Although the large root is wanting in the wild variety, yet there is little else to distinguish it from the cultivated species ; for the leaves, flowers, and even the fruit of the wild carrot are exactly similar to that of the cultivated plant.

The carrot is a biennial, with a stem rising to a height of two feet, leaves compound pinnatifid, flowers white, succeeded by rough hispid seed-vessels, the supporting stalks of which are inflected inwardly, so that the cluster of compact umbels does not look unlike a bird's nest. The root of the wild plant is white, dry, woody, and strongly flavored. Cultivated, the root becomes succulent, and of a red-yellow or pale straw color, showing, in a remarkable way, the improvement which may be effected by cultivation.

The carrot was cultivated at a very early epoch even by the Greeks and Romans. The cultivated garden variety has been most probably derived from the wild form. It is difficult to say how its nutritive character was discovered. We know, however, by the experiments of M. Vilmorin, that the wild carrot sown in good

land becomes similar to the cultivated species at the end of some generations; and inversely that the cultivated carrot returns to the wild form, if planted in bad land, in the course of a few generations.

The CELERY (*Apium graveolens*, L.)—This plant is a hardy biennial, indigenous to Great Britain and different parts of Europe; it has even been found by Hooker in the southern hemisphere, and by Nuttall in California. Wild celery grows by the side of ditches, near the sea, where the water is brackish. Radical leaves, on channelled petioles, green or purplish, stem leaves, ternate, on short petioles, flowers in umbels, axillary, and greenish white. The wild plant is rank, coarse, and suspicious in its appearance, but cultivation transforms it into one of the sweetest and most wholesome of our esculents.

Celery is grown in trenches, and as the plants grow their stems are covered with earth; the light is thus excluded, the stems are blanched, or turn white, and are thus rendered edible. Celery appears to have been first cultivated in Italy, for the word itself is of Italian origin, it having been formerly called Ache in England, which is, in fact, its true English name.

There are in the natural order Umbelliferae two active principles, the narcotic and the aromatic; the former develops itself when these plants are found in moist grounds, and renders them poisonous; the latter principle predominates when the Umbelliferae grow in dry ground. This may help to cause the difference between wild and cultivated celery, which always grows best in a rich, well-drained soil. The process of blanching also doubtless assists in rendering the poison peculiar to the wild plant inert, as the active principles of the leaves of plants are rarely developed when they are deprived of the light.

The PARSLEY (*Petroselinum sativum*).—The parsley is so well known, that a description of it is perfectly unnecessary. It is a hardy biennial, a native of Sardinia, and was introduced into England in 1548. It has naturalized itself in some parts of England on old walls and rocks, usually near the sea. It was used by the Romans as a pot-herb, and was also known to the Greeks. The curled variety of parsley is most common in the gardens, and is the safest to cultivate, as from the beautiful curl of its foliage it cannot be mistaken for the poisonous fool's parsley (*Ethusa cynapium*, L.).

The CABBAGE (*Brassica oleracea*, L.)—This plant belongs to the

natural order Cruciferæ, (*cruz*, a cross; *fero*, to bear,) in allusion to the petals of the flowers, which are four in number, and arranged in the form of a Maltese cross. The horseradish, cress, mustard, and the different variety of cabbage and turnip all belong to the same natural order. This plant grows wild on European seashores, and various places on the English coast—for instance, at Dover and Penzance, where the shores are rocky. The leaves of the wild cabbage are gyrate, glaucous, wavy, the plant occasionally growing from one to two feet in height; flowers light yellow; pods erect. In spring the sea-cabbage may be gathered and eaten. It was no doubt resorted to as food by the early inhabitants of Great Britain long before any attempt was made at cultivation. The Latin word *Brassica* is derived from the Celtic *Bresic*. There is no plant which has produced, by cultivation, a greater number of varieties than the *Brassica oleracea*. The opinion is generally entertained by botanists, that the white and red cabbage, savoy, borecoles, cauliflower, and brocoli, have all originally sprung from the wild cabbage of the sea-coasts. Now when varieties reproduce themselves permanently, they become races, and there is evidence that some of these races have been cultivated in other countries from the earliest times of which we have any record. Take for example the permanent variety of the red cabbage (*Brassica oleracea*, var. *rubra*), now chiefly used for pickling, which was known to the Romans. As the primitive inhabitants of the different European nations had very little communication with each other, it is probable that the wild cabbage (*Brassica oleracea*), which grows on the shores of Denmark, France, and the Mediterranean, furnished in every instance the cultivated varieties of those countries. The cabbage was most likely first grown in Great Britain by the Saxons. It was such a favorite with them, that they called the second month of the year *Sprout-kale*.

Two leading sub-divisions may be effected of nearly all the varieties of the garden cabbage. These varieties are either — 1. Headless cabbages (*Brassica oleracea*, var. *acephala*), such as the borecole, the leaves of which continue expanded, never forming a head; or, 2. Close-headed cabbages (*B. O.*, var. *capitata*), such as the white and red cabbage and the savoy, whose concave leaves are densely imbricated over each other, and form a close compact head before flowering. The word cabbage is, in fact, derived from the Latin *caput*, a head, through the French *cabus*. Brussels sprouts (*B. O.*, var. *subdanda*). This is

only a variety of the savoy, with an elongated stem, from the sides of which spring out small green heads like cabbages in miniature. If the stem be examined, these sprouts will be found invariably to start just above the scars left by the fallen outer leaves. The cauliflower (*B. O., cauliflora*). In the cauliflower we eat the fleshy flower, stalks, and undeveloped buds, which are crowded together into a compact mass. It was a favorite saying of the great lexicographer, Dr. Johnson—"Of all the flowers of the garden, I like the cauliflower the best!" a sentiment worthy of that learned epicure. The cauliflower was first brought from the Isle of Cyprus, about the beginning of the seventeenth century. *Brocoli*.—The name is Italian. This is only a sub-variety of the cauliflower, distinguished from it by the dark green or purple color of the head. It is also a much hardier plant, and stands the winter.

These varieties of the cabbage illustrate in the most striking manner the changes which are produced in species by cultivation, and the permanence of some varieties or races. They also give us instructive lessons in the economy of vegetable life.

The TURNIP (*Brassica campestris*).—This plant is found wild in many parts of England, by the sides of rivers, ditches, and marshes, but is probably an only introduced plant. It grows spontaneously over all Europe, from the Baltic to the Caucasus. The wild form has hispid, lyrate root-leaves; those of the stem are smooth amplexicaule or stem-clasping. The flowers are yellow; the pod cylindric. The turnip, like the cabbage, has produced several varieties, the result of long cultivation, as for example the common cultivated species of turnip (*B. C.*, var. *Rapa*), and the Swedish turnip (*B. C.*, var. *Rutabaga*), the root of which is yellowish and sub-globose. This last variety, which is the most valuable to the British farmer, has long been grown in Sweden and Germany, and was probably known to the ancients. It was first cultivated in England in 1781, having been brought over originally from Gottenberg. Besides these there is another valuable variety (*B. C.*, var. *oleifera*, DC.), which is largely cultivated in France and other European countries for the oil contained in its seeds, which, under the name of Colza oil, is used for lamps, giving a very brilliant light. The idea of cultivating these plants for the oil contained in their seeds could only originate in those countries where the olive was not introduced, or yielded uncertain crops. Colza oil has been used for more than two centuries in the north of France, and its use probably dates back to a still more ancient period. The Greeks and

Romans, the Celts and Germans, cultivated the turnip; its original country is doubtful on account of the facility with which it becomes naturalized outside of cultivated ground. M. Fries says that *Brassica campestris* and *Brassica rapa* grow spontaneously in the Scandinavian peninsula; and within the last few years the explorations of the French naturalist, M. Ledebow, in northern and eastern Europe, have shown that both these plants are spontaneous through the whole of Russia and Siberia.

The HORSERADISH (*Cochlearia Armoracea*, L.)—This is the last of the crucifers whose natural history we shall discuss. It is cultivated for its root, the merits of which are well-known in connection with the “Roast Beef of Old England.” We shall not occupy the time of our readers with a botanical description of this well-known plant, the cultivation of which is of undoubted antiquity, as it was used in the time of Pliny, the Roman historian. When planted in gardens it is very difficult to eradicate, as the rhizome is furnished with many eyes, each of which will give rise to a new plant. The horseradish is very frequently found growing outside of cultivated ground, on the banks of rivers, and in most situations, but it is very doubtful whether it is indigenous in England. It is, however, a native of many parts of Europe. The root owes its qualities to the presence of a volatile oil which is dissipated by drying. There is no difference between the wild and cultivated plant, except that the root of the former is smaller and more stringy if it happens to grow in a poor soil; but if the soil should be moist and rich in which it is found, then the root of the wild plant is equally good.

We would recommend our readers, if they have leisure, to prosecute this inquiry, as it will be found most interesting in connection with the early periods of human history. It is also an important inquiry, because it has a direct bearing on those formidable questions as to the “Origin of Species,” as to the amount of variability of which species are susceptible, and the causes by which that variability is produced: and lastly, as to the geological epoch at which existing species were first introduced—questions which the best naturalists find it so difficult to answer, and which will only be understood when natural history is much more advanced, and the links discovered which unite the present plant-forms with those which have preceded them.

We have historical evidence that existing species have not varied for several thousand years, and the reason is plain enough, because

the external circumstances in which they have been placed have not varied. For all practical purposes, therefore, the characters on which species are found may be assumed to be constant; and a minute and careful description of a plant will suffice, not only for the present, but for many succeeding generations of naturalists. But we have no warrant from nature to assume that such specific, or even generic, characteristics either have been, or will continue to be, permanent for an unlimited period of time, that they will survive all future changes in the physical geography of the planetary surface. We know that great changes may be effected in a brief space of time in the organization of plants by cultivation; and why should not an organic change be brought about in plants when their external circumstances are altered by nature in the course of ages? This world, what is it but a great and ancient theatre where the scenery of life is ever changing? Look at that majestic and venerable tree; its present form appears to be fixed, yet that very form is in reality as fleeting and evanescent as all the other forms through which that tree has passed from its first life movement in the seed; and what is true of that tree, which is a part of nature, is true of the whole of nature. The present appearance of nature now is no more unalterable than at any other geological epoch. It is the last of the many phases of creation, and equally fleeting with all the others.—*Popular Science Review*.

ON THE GRAPTOLITES OF THE QUEBEC GROUP.

By PROFESSOR JAMES HALL.

[This long-expected monograph* is now before us, and has grown in magnitude under the delays which have attended its publication, until, instead of one decade, it contains no less than twenty-three admirable plates, with one hundred and fifty pages of letter-press.

Prof. Hall gives to the *Graptolitidæ* the rank of a family, including fifteen genera, of which no less than eleven occur in the Quebec group, this being, so far as known, the period of the greatest development of these curious organisms. The species

* Decade II of Canadian Organic Remains, issued by the Geological Survey of Canada. Dawson Bros., Montreal; Ballière, London, New York, and Paris.

occurring in the Quebec group of Canada, and described in this memoir, are fifty-three in number.

The affinities of the graptolites have been a subject of much discussion. Prof. Hall, after noticing the various opinions which have been entertained, shows good reasons for the view that they were Hydroids, approaching to the modern *Sertularidæ*, a view which General Portlock has also maintained. We quote somewhat at length the statements bearing on this point, referring our readers to the work itself for the details of structure and systematic descriptions.—Eds.]

Until recently the graptolites were, with two or three exceptions, known only as simple, straight, or slightly-curving linear stipes or stems, usually lying in the same plane upon the slaty laminæ in which they were imbedded. Nearly all these were evidently fragmentary, and, though varying somewhat in their proportions, rarely exhibited anything that could be regarded as the commencement or termination of their growth or development. These bodies, in their flattened condition, present a range of serratures either on one or on both sides of the stipe; and seldom preserve more of their substance than a carbonaceous or corneous film or test of extreme tenuity. Under more favorable circumstances, these serratures are discovered to indicate the apertures of cellules, symmetrically arranged in reference to each other, and to the axis of the linear stipe. Others show parallel entire margins, with transverse indentations across the central portion of the stipe. This appearance we now know to be due to the direction of the pressure upon the body exerted at right angles to the cellules, and which will be explained in the sequel.

The earliest opinion regarding these fossils was that they were of vegetable origin; and they have been thus considered by some authors even at a very late period. Subsequently, they were referred by Wahlenburg, and after him by Schlotheim, to the Cephalopoda, being regarded as extremely slender orthoceratites. This opinion may have received support from specimens in such condition as *G. scalaris*, where the indentations are limited on each side by a continuous margin; but in such as present a single or double series of marginal serratures, the analogy seems very remote. Professors Geinitz and Quenstedt advocated the same view at a much later date; though it has since been abandoned by these authors, from more extended investigations.

Professor Nilsson first suggested that graptolites were Polyparia, belonging to the family Ceratophyta. Dr. Beck, of Copenhagen, regarded them as belonging to the group Pennatulidæ, of which the Linnean *Virgularia* is the most nearly allied existing form. Sir Roderick Murchison has adopted this view of the relations of the graptolites, in his *Silurian System*.^{*} General Portlock has fully recognized the graptolites as zoophytes, and has pointed out their analogy with *Sertularia* and *Plumularia*.

The relations of graptolites with the Cephalopoda had already been fully disproved by M. Barrande (in the first chapter of his *Graptolites de Bohème*), before the abundant materials for the refutation were discovered in the graptolites of the Quebec group; and most naturalists were already agreed in referring these bodies to the class of Polypi, to which they doubtless belong.

More recently, Mr. McCrady, of South Carolina, has published a paper on the "Zoological Affinities of Graptolites,"[†] in which he has endeavored to show the similarity of the graptolitic forms with the Echinoderm larvæ, as illustrated by Müller. There is certainly much resemblance between the enlarged figures of that author, and some forms of graptolites in the shales of the Hudson River valley; while some of the figures with central discs have a more remote analogy with certain forms from the Quebec group. Some of the toothed rods of the Echinoderm larvæ likewise bear a resemblance to the graptolites figured by Mr. Suess;[‡] and there are still further analogies pointed out by Mr. McCrady, which, however, may not be regarded as of equal value by the greater number of naturalists.

For my own part, although admitting the similarity of form and of some of the characteristics which were very kindly pointed out to me by Mr. McCrady, long before his publication, I cannot recognize the analogy sought to be demonstrated. The establishment of the fact that these toothlets or serratures are the extensions of true cellules, each one having an independent aperture,

^{*} *Silurian System*, page 694; and letter of Dr. Beck, pp. 695-6.

[†] "Remarks on the Zoological Affinities of the Graptolites, by John McCrady, made before the Eliot Society of Natural History of Charleston, S. C., at the meeting of July 15, 1857." [Extract from the Proceedings, vol. i.]

[‡] *Naturwissenschaftliche Abhandlungen*. Vierter Band. Tab. viii and ix.

and communicating with a common canal, should offer a convincing argument against these bodies being other than polyp-bearing skeletons. But in following the extensive series of forms now presented to us, we have much evidence to show that some of these were attached to the bed of the ocean, or to other bodies; while the greater proportion of the species and genera appear to have never been attached to the sea-bottom.

It may not be easy to determine precisely the family to which these graptolitic forms should be referred; nor is it certain that the extensive series now presented can all properly be referred to a single family. General Portlock has suggested that these bodies may constitute "several genera belonging even to more than one order."* That they are true Polypi, I believe we shall be able to show, both from analogies already established by various authors, and also from their mode of development or reproduction as exhibited in some of the species.

The specimens which have usually been observed or represented are simple disconnected stipes, doubtless the dismembered or fragmentary portions of fronds, which, presenting in the different species great varieties of form and aspect when entire, are nevertheless composed of parts so similar that these fragments, though indicating specific differences, offer little clue to a knowledge of the entire form.

The name *Graptolithus* was established by Linnæus in the first edition of his "*Systema Naturæ*," 1736, and applied by him to the straight or curved forms which are serrated (celluliferous) upon one side only, of which *G. sagittarius* has been regarded as the type.† The propriety of this term is more readily perceived in its application to the fragments of the stipes of monopronidian forms than to the central portions of the body of the same. In the spirally-enrolled forms, or those with four or more stipes uniting in the central disc, as well as in the variously-branching forms, the analogy is not so perceptible.

1. The Solid Axis.—All the graptolites proper have been found to be provided with a slender solid axis,‡ while this feature has

* Geological Report on Londonderry, &c., p. 318.

† I shall elsewhere endeavor to show that *G. scalaris* is a diprionidian form exhibiting only one margin.

‡ In those species with a single series of cellules, M. Barrande has ascertained that this axis is solid and cylindrical, its diameter not exceeding $\frac{1}{4}$ millimetre, and its structure apparently fibrous. (*Graptolites de Bohème*, page 4.)

not been satisfactorily proved in regard to *Dictyonema*, and to some other forms.

In those species having a single series of cellules, this axis is upon the back of the stipe, or on the side opposite to the celluliferous margin; and in the branching forms it follows all the ramifications. In all the specimens where it has been observed, it is a slender cylindrical or flattened filiform solid body. In some extremely compressed specimens, this axis appears as a slender elevated ridge along the back of the stipe; and where the substance of the body has been removed, it leaves a narrow groove along the margin of the impression.

In the examination of large numbers of specimens of the monoprionidian species, we have never found the axis prolonged beyond or denuded of, the cellules; as shown in *G. colonus*, by Barrande, in his Graptolites of Bohemia.

In all the specimens where the extremities of the stipes are entire, (as represented in plates i, ii, and iii of the memoir,) there is never any extension of the axis beyond the last partially developed cellule; and the number of specimens in this condition is considerable.

In the graptolites with two series of cellules, the solid axis is very frequently seen extending beyond the celluliferous portion of the stipe at its outer extremity; while the radicle appears like the continuation of the same below the base. The axis thus appears to be the foundation on which the other parts are erected. In those specimens, however, which present so great an extension of the solid axis beyond the stipe, the cellules may have been removed by subsequent causes.

I am able to corroborate to some extent the observations of M. Barrande in regard to the apparent double character of this axis. In some extremely compressed specimens it is marked by a longitudinal groove or line of division;* while in others, a double impression has been left by the removal of the substance.

2. The Common Canal.—In all graptolites with a single series of cellules, there is, between the bases of these cellules proper and the solid axis on the back of the stipe, a continuous sub-cylindrical space or canal, which has been occupied by the body of the polyp,

* The aspect presented by the axis, when marked by a longitudinal groove, is precisely that which a hollow cylindrical body would have if extremely compressed.

from which the buds, with their calyces forming the cellules, take their origin, and are thrown off at regular intervals.

All the specimens which I have examined confirm this view; and in some of the species where the extremities are apparently entire, we observe the incipient development of the young cell from the common body. In those specimens filled or partly filled with the substance of the surrounding rock, this canal is easily distinguished; while in compressed specimens there is always a flattened space between the bases of the cell-partitions and the solid axis.

In those graptolites with two ranges of cellules, we have apparently a duplication of those with the single series, the two solid axes being joined together, leaving a common canal or body on each side at the base of each series of cellules. If however the common body were thus divided, it would be by the solid axis, becoming a flattened plate. This appears to be true of some species, while in others there is only a simple filiform axis visible. In this case, of course, there is not an entire division in the common canal after the manner of the other species. This will appear further on, under the illustrations of the structure of these bodies.

3. The Calyces or Cellules; their form and mode of development.—Since a large proportion of the specimens of graptolites which come under our observation for the purposes of study or otherwise, are fragmentary, it becomes of much importance to know the general characters of form and mode of development of the cellules.

In the preceding section it has been shown that the cellules, or the inhabitants of these cellules, are not independent, but all have their origin in a common body, which fills the longitudinal canal, and that they remain in constant connection with the same throughout their existence.

The calycle or cellule is formed by budding from one side of the common body, not unlike many of the Sertularians, except that the cellules are generally close together at their origin. They are usually more or less oblique to the direction of the axis, as is clearly indicated by the cell-partitions; and the degree of obliquity often indicates specific distinction. The cellules are for the most part contiguous at their origin, and they sometimes remain in contact throughout their entire length; but in the greater number of species there is a small portion of each one free on one side towards the aperture. This character is shown in numerous examples.

In some forms the cellules are contiguous in their lower portions, while the entire upper or outer part becomes free, as seen in *G. Clintonensis*, while in one of the bi-celluliferous species from Iowa, the cellules are distant from each other at the origin, and the upper extremity of one scarcely reaches to the base of the next in advance, and they are therefore not properly in contact in any part of their length. The same is more emphatically true of *Rastrites*, where there is a large interval between the bases of the cellules, which are often nearly rectangular to the axis.

Although we regard the cellule as limited by the cell-partitions, yet in well-preserved specimens there is sometimes a swelling of the test of the common body below the cellule, indicating an enlargement of the parts at the bases of the buds. In one species there is an evident undulation of the axis, corresponding to this enlargement of the parts in the common body.

In the diprionidian species, the cellules on the two sides of the stipe are alternating, so that the bases or the apertures are opposite the space between two others.

In much the larger proportion of species, the body of the graptolite and the cellules are so extremely compressed, that they appear only as serratures along the margin, with distinct impressed lines marking the cell-divisions. The exterior margin of these serratures indicates in an approximate degree the outline of the aperture; and the frequently-occurring mucronate extension at the extremity of the cellule is produced by the continuation of the cell-partition, or sometimes by an outgrowth from the margin of the stipe above or below the aperture.

Were the cellules isolated, their prevailing form would be that of an elliptical tube or sac, the length of which is greater than either of the two diameters. When they are in juxtaposition, however, the contiguous sides are flattened, while the lateral or external surfaces are usually more or less curved, particularly near the aperture. In a larger proportion of the species, the calycle becomes slightly expanded towards the aperture; but in a few examples there is a distinct contraction above the middle, and the aperture is smaller than the base. Generally, however, the smaller diameter is just at the junction with the common body, or at the junction of the cell-walls with the walls of the common canal.

In a single diprionidian species, where the specimens are not

distorted by pressure, a longitudinal section of the stipe in the direction of its greatest diameter shows the cellules scarcely narrowed at their origin with the common body; while in a lateral view of the specimen, the base of the cellule is seen to be much wider than the orifice.

In many of the species a transverse section of the cellule near the base is quadrangular, becoming more rounded towards the aperture; and when the upper part of the cellule is free, the aperture is round or elliptical, and in some specimens the calycle is elliptical or cylindrical throughout its entire length. We have examples of the quadrangular cellules in *G. extensus* and *G. octobrachiatus*, as well as in two species of *Phyllograptus*. Where the cellules are more nearly isolated, they approach more and more to the cylindrical form. As examples of cellules contracted towards the aperture, we have *Graptolithus priodon*, Barrande, and *G. Clintonensis*, Hall. * * * * *

In 1858, I laid before the American Association for the Advancement of Science a notice, with some illustrations of graptolite stipes, bearing what I then regarded, and do still regard, as the reproductive cells or ovarian vesicles. These cells first appear as small ovate buds upon the margins, projecting but little beyond the regular cellules, and, becoming enlarged, form elongated sacs with swollen extremities, which are finally dehiscent; and then, as I suppose, discharging the ovules or germs, are gradually absorbed or dissipated.

Although these sacs are distinctly defined, they have scarcely any apparent substance, except along the lateral margins, which are limited by a filiform extension resembling the solid axis of a graptolite. There are likewise numerous fibres of this kind traversing the sacs; and these sometimes remain attached to the original stipe after the other parts are separated. In one example we have conclusive evidence that they are connected with the solid axis of the parent stipe.

In one specimen the ordinary cellules are removed, and the fibres are still seen joined to the axis, showing the origin of the reproductive sacs. In most specimens bearing these sacs, the cellules of the stipe are so obscure that the species cannot be determined; but in one case we find them attached to a well-marked type of *G. Whitfieldi*.

This mode of reproduction in the graptolites shows much analogy

with the Hydroidea, and would indicate the sertularians as their nearest analogues.*

Upon the surfaces of the slate where these bodies occur, there are numerous graptolitic germs, or young graptolites of extremely minute proportions, ranging from those where the first indications of their form can be discovered, through successive stages of development till they have assumed the determinate characters of the species.

In several examples, these minute germs have been detected near to and in contact with the reproductive sac; and in one case, there is but a hair's-breadth between one of the fibres of the sac and one of the oblique processes at the base of the germ. It cannot be said that we have detected the germ actually within the sac; but the numerous young individuals lying near them, and upon the surfaces of the same laminæ, offer very good arguments for supposing that they have been thus derived.

The earliest defined form which we observe in the young graptolites consists of the initial point or radicle; a diverging process of similar character on each side, but not quite opposite; a longitudinal axis of greater or less extent; and a sac-like covering, or thin pellicle of graptolitic test, which has scarcely assumed the form of cellules, but which is most extended in the direction of the common body along the solid axis. This little sac contains the germ of the zoophyte, which, extending itself as the common body in its canal along the axis, gives origin to the budding which develops the successive cellules and the gradual building up of the stipe. * * * * *

The numerous individuals of entire or nearly entire fronds illustrated in this memoir, as well as large numbers of others examined, serve to give a pretty clear idea of the general form of

* In the recent *Sertularia* and *Campanularia* we find ovarian vesicles, in which a number of ovules may be enclosed in a common envelope. These vesicles are developed along the side of a stipe or branch, and the ovules are often arranged along a central axis, each one communicating with the common axis of the zoophyte. [Jas. J. Lister, *Philosophical Transactions*, 1834, pp. 365-388, pl. ix. Cited also by Dana, "*Structure and Classification of Zoophytes*."]

Prof. McCoy has stated (*British Palæozoic Fossils*, p. 4) that he has found near the base of the cellules of graptolites, a transverse partition or diaphragm, similar to what may be observed in some sertularians and which he regards as proving similar relations; but I have not discovered in any American specimens evidence of such cell-diaphragms.

the true graptolites, as well as of their congeners of the same family. Notwithstanding the presence of the radicle or initial point observable in so many species, it does not afford evidence of attachment to the sea-bottom or to some other substance, at least in the mature condition. In all the monoprionidian forms, however much or little extended the radicle may be, it is always smooth, and tapering to a point. In many of these, and more especially in those with a central disc, this radicle is reduced to a minute protuberance, and is often scarcely or not at all perceptible.

The same is essentially true of the greater number of diprionidian forms examined. In these the solid axis is sometimes extended beyond the base of the stipe, and terminated as if broken off abruptly; while there is often a slender oblique process on each side of the base.

In *Retiograptus* and *Phyllograptus* there is not the same evidence of completeness at the base of the radicle. The lower termination, when it can be fully examined, is broken, as if there had been a further continuation of this part, though it exhibits no enlargement. I have inferred that all these, like the example of *Retiograptus eucharis*, have constituted parts of a similar compound body, and are but the separated stipes of the frond. If this be true, their mode of existence is not unlike the other species with compound fronds and a central disc.

In *G. bicornis* the extension of the solid axis below the base of the stipe is not always preserved; but when it is entire, we find two strong diverging and slightly-curving processes or spines from the base, having smooth terminations. Sometimes a disc or bulb, of the same substance as the stipe, extends between these spines, and in the compressed condition envelops a few of the lower cells.

The expansion at the base of this species has the same general appearance as the central disc of *G. Logani*, *G. Headi*, and others; showing that this sort of development of the substance is not alone characteristic of those forms having several stipes united at the base. In other examples this basal expansion is contracted in such a manner as to give a crescent-form to the lower extremity; but in all these gradations, the margins of this part are entire and unbroken.

We have seen that the youngest forms of the diprionidian graptolites, those which we may suppose had but recently escaped from the reproductive sac, are furnished with the minute radicle-

like appendage or extension of the solid axis, as well as the oblique lateral processes like tentacula; and the condition of these parts does not seem to have been essentially changed during any subsequent period of their growth. While the extension of this slender solid axis does not seem to have sufficient strength to have formed the base of attachment to the sea-bottom, it may have been sufficient to maintain connection with other parts of a compound frond.

For all those species with a single range of cellules, as well as for some with a double range, including *Retiolites*, *Retiograptus*, and *Phyllograptus*, I conceive that we have already shown a similar plan of development and a uniform mode of existence; and we are constrained to believe that all these forms, in their mature condition, were free floating bodies in the Silurian seas.

In regard to another group, including *Dendrograptus*, *Callograptus*, *Dictyonema*, as well as one or two other forms, we have some evidence indicative of a different mode of existence. The stems of *Dendrograptus* are enlarged towards their base, and sometimes present a sudden expansion or bulb, which I have inferred may be the base or root, once attached to another substance or imbedded in the mud. The general form of the species conduces to the belief that they were fixed to the sea-bottom, though possibly this basal expansion may have resembled that of *Graptolithus bicornis*. In most of the species described, the lower extremity is imperfect, and its termination unknown.

In those which I have termed *Callograptus*, the bases of the fronds are imperfect, but indicate, according to analogy, a radicle or point of attachment like *Dendrograptus*. In the more nearly entire forms of *Dictyonema* known, we have not been able to observe the base; but from their similarity in form and mode of growth to *Fenestella* and *Retepora*, we have inferred their attachment either to the sea-bottom or to foreign bodies.

Nearly all these forms occur in rocks where there are few of the larger fossils of any kind except the graptolites; so that there is little chance of finding their bases attached to shells and corals, as we do those of the bryozoans, even if they had thus existed. The *Dictyonemæ* of the Niagara, Upper Helderberg, and Hamilton groups do occur in strata which contain large numbers of other fossils; but we have no evidence of their having been attached. It is only from their general form therefore, and from their analogy

with other bodies, that we infer that these genera may have been attached to the sea-bottom or to some objects during their growth.

We admit therefore that the family of Graptolitidæ, as now extended, may include both free and fixed forms *

A FEW NOTES ON THE NIGHT-HERON.

By HENRY G. VENNOR.

While our little hawk-owl (*Surnia ulula*) ranks as an intermediate species between the hawks and the owls proper, our NIGHT-HERON shares partly the structure of both heron and bittern; its habits, food, and color of eggs are however decidedly those of the heron. It is called night-heron from its nocturnal habits, and has been thus described:—"Bill black; crown, hind head, back, and scapulars, glossy blackish green; from the hind head proceed three long, rounded, pure white feathers or plumes; wings, rump, and tail, light ash-color; neck, and lower parts, a white, with the most delicate tinge of cream-color; iris, fiery red; legs, yellow? Length of the adult bird, from twenty-six to twenty-eight inches; extent four feet." The young bird has not the head-plumes. About the middle or end of March, numbers of these birds leave their winter-quarters in the Southern United States (where many remain all the year round), and proceed northward, settling down in squads,—some along the Atlantic coast, others on the river-shores and marshes of the Middle States, while a small number reach the borders of Canada, about the middle of April. At the foot of the Lachine rapids, in the St. Lawrence, is Nun's Island, on the upper part of which, and hardly out of hearing of the city noise, many rare and beautiful birds spend their breeding-season in peace and quiet, and among others the night-heron. I have tried, in vain, to discover the period when these birds first visited and built in this island. From all accounts, and judging from the appearance of the heronry, it is very ancient. It is a well-known habit of these birds to return year after year to their favorite breeding-grounds; and it is only when the trees have been felled, or they have been unusually persecuted, that they will forsake an old locality. Not only do they frequent

* Several papers on the Graptolites will be found in the previous volumes of this journal. See especially the volume for 1858, pp. 139, 161.

yearly the same locality, but often the same pair return to the same nest; and as their numbers increase, the new-comers build nests for themselves. The heronry at Nun's Island may have been commenced by only two or three pairs of birds; but as old and young returned year after year, the number of nests has thereby greatly increased: during the summer of 1864 I estimated the number of breeding birds at from eighty to one hundred pairs. Having visited it for several successive years, I have seen the birds in every stage of plumage. So like are the male and the female that the most practised eye cannot tell the one from the other. Like the male, the female has the long, white occipital plumes on the hind head. These are in most cases three in number, but specimens are often found with four perfect plumes. Many mistakes have been made by collectors respecting the male, female, and young, of this species; the one being often taken for the other. The young of the first year may easily be known by the following general description:—"The upper parts light brown, streaked with reddish white, the lower parts being dull ashy-white, variegated with grayish, and dusky."—Public and private collections would be doubly valuable, in a scientific point of view, were they to have a young bird of each species placed beside the adult male and female. Great difficulty has been experienced in determining certain species of eagles, hawks, and falcons, owing to the diversity in plumage of the different sexes, and at various stages of growth.—But to return to our subject. The trees in the heronry above alluded to are not scattered far apart, but they may be enclosed by a circle of about one hundred and fifty or two hundred yards in diameter. The nests are built often two and three on the same tree; and in many cases side by side with those of the American crow. Their nests are not unlike one another, that of the crow being however smaller. The heron's nest is composed of sticks thrown together very loosely and carelessly; often indeed with so slight a hollow, as to endanger the safety of the eggs and young. Many eggs are thus destroyed: after a high wind, the ground is often strewn with the broken shells. The eggs, so far as I have observed, are always four in number, and of a light blue-color,—agreeing in these respects with those of the night-heron of Europe. During the day, the male birds roost on lofty trees near the water's edge, uttering from time to time their harsh croak,—the females meanwhile keeping to their nests. When

approached, they rise in the air with a great uproar, and watch the intruder, but take care to keep at a respectful distance. No sooner has night set in, than, leaving their roosts, they scatter along the shore or around the marsh in search of food. This consists chiefly of small fish, water and marsh insects, and reptiles—as water-newts, lizards, and small frogs. Their flesh, though seldom forming a table-dish in Canada, is esteemed excellent, having the flavor of the hare. We hope, however, that these birds may long continue to breed in our midst, and quietly accomplish their useful mission of keeping down the undue increase of injurious reptiles, protected by naturalists, and undisturbed by pot-hunters.

Let us now look at its variety—if variety it be—occurring in Europe. Our American bird, as we have before noted, is from twenty-six to twenty-eight inches in length. In India, we find that what we suppose to be the same species is only twenty-four inches in length; while in Europe it measures only twenty-two inches. Looking at the habits of this bird in these different places, we note, that in America it chooses, whenever possible, lofty trees to build upon, and these always near good feeding-grounds. In India and in Europe however, where marshes are not bordered by such trees, the heron at once selects either a small tree or bush for its nest, and in many cases even builds on the ground.

How then are these differences in size and habits to be accounted for, if we maintain that the herons found in these different places are of one species? From observing the habits of these birds, we have come to the conclusion that the heron, in fixing upon its breeding-ground, is chiefly influenced by the suitableness of the locality for its favorite food. Rarely do we find heronries at any great distance from good feeding-grounds. Is it out of the way, then, that we should find this bird, where there are no trees, choosing a bush or even the ground? We should not infer, because it builds in a bush or on the ground, that this is its natural habit, but rather a turning out of its regular course so as to be within easy reach of its food. This circumstance explains, we believe, not only the slight difference in habit, but also the diversity in size. For we would ask, where are these birds most at home? Where may observers note their natural habits? We have seen that the night-heron of America is larger than that of Europe or of India; that in America they build and breed together in large companies, and always choose lofty

trees, where such are to be had near their feeding-grounds; and that though some individuals in America build among bushes and even on the ground, they are few in number and exceptions to the general rule. Is not America, then, their natural place of abode? We find, on turning to Europe and India, these birds decreasing in size, and building their nests in the best situation the locality affords;—and just as we see them thus as it were forced out of their natural choice of breeding-grounds, so we find them suffering in consequence, and becoming smaller; though their plumage and general characters remain unchanged, agreeing precisely with our American species. Next to that of the continent of America, we would place the heron of India, and lastly the smaller bird of Europe, where I think it is not at all at home.

In closing these few notes, I would ask, are there not many birds of other continents, differing but slightly in form and habits with similar species on our own, set down and named as distinct species? and might not a careful investigation into their habits and necessities, enable us to fix upon their natural home, and set down many as one species, though, like the night-heron, they may be found in a greater or less variety of form?

[Prof. Baird, one of the best authorities on American ornithology, considers the night-heron of America distinct from the European species. At the same time it is unfortunately too common for American authors to attach undue importance to minute points of difference between birds inhabiting the eastern and western sides of the Atlantic. There are many birds, *e. g.* the osprey and the crow, respecting which a similar parallel to our author's case might be drawn; and we have little doubt that, with extended knowledge, many more species than is usually supposed will be found to inhabit both continents. We would suggest the necessity of carefully comparing a large series of European and Indian skins with American specimens, before passing final judgment on this oft-mooted question. The size of specimens from any locality varies much; and, as far as we remember, the night-heron in England usually breeds in trees.—J. F. W.]

ENTOMOLOGICAL SOCIETY OF CANADA,

QUEBEC BRANCH.

The first annual meeting of the Society was held in the rooms of the Literary and Historical Society, on Thursday, 5th January, 1865, at half-past seven o'clock, p. m., the President, Mr. F. J. S. Dore, in the chair.

The minutes of the previous meeting were read and confirmed.

The Rev. L. C. Wurtele, B.A., of Actonvale, C. E., and Mr. R. P. Davis, of Quebec, were elected members of the Society.

The following donations to the cabinet were announced :

From A. L. Russell, Esq.

45 specimens	Coleoptera, comprising 27 species.			
9	"	Hemiptera,	"	6 "
4	"	Orthoptera,	"	4 "

From G. J. Bowles, Esq.

24 specimens	Lepidoptera, comprising 22 species.			
2	"	Neuroptera,	"	2 "

From W. Couper, Esq.

203 specimens	Lepidoptera, comprising 143 species.			
170	"	Coleoptera,	"	130 "
29	"	Hymenoptera,	"	18 "
3	"	Orthoptera,	"	3 "
173	"	Diptera,	"	40 "
13	"	Neuroptera,	"	9 "
34	"	Hemiptera,	"	25 "

From R. H. Browne, Esq.

12 specimens	Lepidoptera, comprising 12 species.			
1	"	Orthoptera,	"	1 "

From the Abbé Brunet.

25 specimens	Coleoptera, comprising 16 species.			
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A number of entomological pamphlets were also presented to the library by different members.

Mr. Couper exhibited eleven new species of Canadian Coleoptera, and presented for publication the several descriptions.

The following report of the retiring Council was then read by the president :

The Council of the Quebec Branch, Entomological Society of Canada, in presenting its First Annual Report, would congratu-

late the members on the success which has attended this the first attempt to promote the study of entomology in Quebec. A year ago, the students of the science in this city were very few; but the establishment of this Branch has already nearly tripled their number, and an interest has been awakened, which argues well for the progress in Lower Canada of this interesting department of Natural History.

The founders of this Society considered, that instead of forming a distinct organization, it would be more advantageous to unite themselves with the Entomological Society of Canada, located at Toronto. They therefore made certain proposals to that Society, resulting in an arrangement which your Council believes will tend to the prosperity and stability of this Branch, and to the advancement of Canadian Entomology. The members of this Branch enjoy the privileges of membership in the parent Society, with the additional advantages of having their own officers and by-laws, and of holding meetings among themselves. It is satisfactory to notice that the entomologists of London, C. W., have perceived the benefits of a similar arrangement, and have united with the society at Toronto, under the name of the "London Branch." No doubt this course will be followed by the students in other parts of Canada, and a strong society thus be formed, which will successfully carry out the study of the insect-fauna of Canada.

An agreement was also made with the Literary and Historical Society of Quebec, which will prove mutually beneficial,—in lessening the necessary expenses of this Branch, and in providing for the museum of that Society a good collection of our insects.

This Branch now numbers ten members, and two gentlemen were proposed at the last general meeting of the year. Considerable progress has been made in the formation of private collections; but as the majority of the members are beginners, only four papers have been presented to the Society during the year. Two of these have been published in the "Canadian Naturalist," Montreal, and the third and fourth will appear in its next issue. The titles of these papers are—

On the larva of *Attacus polyphemus*, by W. Couper.

On the occurrence of *Pieris rapæ* in Canada, by G. J. Bowles.

On a gall-producing Hymenopter, taken upon *Triticum repens*, Linn., by W. Couper.

Descriptions of eleven new species of Canadian Coleoptera, by Wm. Couper.

Mr. Couper has also published a list of the Coleoptera and Diptera taken in the vicinity of Quebec, and in other parts of Lower Canada; and is preparing a continuation of this list, of species determined since. Both of these articles are contributed to the transactions of the Literary and Historical Society.

The Council would also notice, that the Vice-President and Curator of this Branch recently paid a visit to the United States, where they had interviews with many of the eminent entomologists, and did much to create a friendly feeling between the students of the science in that country and in Canada.

The Literary and Historical Society has, according to agreement, provided a handsome cabinet, which is now ready for specimens. Your Council solicits donations, and trusts that a large collection may be made during the coming year.

With respect to the future working of the Society, your Council beg leave to offer one or two suggestions.

Last season, the London Branch had weekly excursions; the members leaving early in the morning, and returning about noon, so as not to interfere too much with business. Your Council would recommend this Branch to adopt a similar plan, if it could possibly be carried out. The vicinity of Quebec is, in many respects, a new field for the entomologist, and these excursions would yield much useful information, as well as healthful pleasure to the students of the science.

It is also desirable that the practical value of entomology should be made known to the public. Your Council would therefore suggest that a few short articles on the insects injurious to agriculture should be prepared for publication, in both languages, in the newspapers of this city. The Society at Toronto has a column in the "Canada Farmer" set apart for such articles.

The Secretary-Treasurer's books and vouchers have been examined, and found correct.

The whole respectfully submitted,

FRED. J. S. DORE, *President.*

Quebec, 5th Jan., 1865.

Resolved: That the report be received, adopted, and forwarded to the "Canadian Naturalist" for publication.

The suggestions of the Council with regard to excursions, and the publication of articles on noxious insects, were discussed and

approved of by the meeting. It was also proposed that the Council should publish a small pamphlet giving directions for capturing and preserving insects, as the best means of obtaining specimens from the Lower St. Lawrence and Labrador coasts.

The following were then elected officers for the current year:—President, F. J. S. Dore; Vice-President, the Abbé Brunet, Prof. Botany, Laval University; Secretary-Treasurer, G. J. Bowles; Curator, W. Couper; Members of the Council, R. H. Browne, A. L. Russell, and G. C. Gibsone.

A number of rare and beautiful insects were on the table for inspection by the members. Among these were *Melitæa phæton*, *Saturnia maia*, *Thecla mopsus*, *Thecla falacer*, *Arctia parthenos*; *Cicindela macra*, *Cychrus marginatus*, *C. stenostomus*, *Carabus vinctus*, *Dicælus sculptilis*, *Megasoma thersites*, *Prionus laticollis*, *Callichroma splendidum*, *Saperda oreata*, *Saperda Fayi*. The ten last-named species are from the United States, and belong to Mr. Couper. The Abbé Brunet exhibited two cases of French Coleoptera.

DESCRIPTIONS OF NEW SPECIES OF CANADIAN COLEOPTERA.

BY WILLIAM COUPER, Quebec.

1. *AMARA PYGMEA*.—Black; thorax margined, longitudinally channelled in the centre; with a double impression and interspersed punctures near the posterior margin. Elytra with nine punctured striæ, punctures profound on the dorsal region, but obscure laterally and posteriorly. Sutural striæ slightly bent towards the region of scutellum; second stria (composed of about ten punctures) joins the third, and runs obliquely towards the sutural stria, but does not join it; the sixth stria shortest posteriorly. Antennæ, palpi, legs, and underparts of body chestnut. Length $\frac{1}{4}$ inch. Quebec; rare.

Similar in form but much smaller than *Amara avida*, Say. In the latter the thoracic discoidal channel is deeper, and the punctures near the posterior angles are more diffused. The first or sutural striæ of elytra are abbreviated, and join the second; while in *A. pygmaea* the first elytral stria is entire, and the tibiæ are very spinose, especially the anterior pair.

2. *GYRINUS FRATERNUS*.—Head, antennæ, and thorax black, highly polished, the latter margined anteriorly with a single row

of fine punctures which may be traced on the lateral and posterior margins. Scutellum distinct. Elytra black, polished, each elytron having eleven rows of fine shining punctures—the first lateral row terminates where the second and third take the form of a crescent on the margin of the apex; the fourth and fifth are joined; the sixth, seventh, tenth, and eleventh join near the sutural margin, and the eighth and ninth are the shortest, and like the fourth and fifth join at their termination. There is a stria on each side of the suture, and the latter has a golden tinge. Body beneath and epipleuræ chestnut, but the legs are of a brighter color. The posterior tarsi are much larger than the anterior pair. The abdomen is longer than the elytra, and rounded at tip. Length $\frac{4}{16}$ inch. Common in ponds near Quebec, June and July.

Dr. LeConte has expressed a doubt regarding the above. On the strength of his knowledge of the species already catalogued, I describe it as an addition to the list of Canadian Coleoptera. Kirby describes two species, neither of which agree with the above. The descriptions of the *Gyrinidæ* in "Fauna Boreali Americana" are imperfect:—*G. impressicollis*, Kirby, and *G. ventralis*, Kirby, have not the row of punctures on the anterior margin of thorax. The northern species described by Say and others, are almost all identified by Dr. LeConte.

3. *BOLETOBIUS BIMACULATUS*.—Head black; thorax testaceous, polished and darker on the disc. Elytra testaceous, smooth-margined on the suture, and having a black spot on each elytrum. Mouth and legs testaceous. Margin of abdominal rings chestnut, posterior one black, acute. Length $\frac{4}{16}$ inch. Quebec; rare.

This species can be easily known from the conspicuous oblong black spot on each elytron. The spots join the epipleuræ, which are black. It is also finely punctured underneath.

4. *ATHOUS AFFINIS*.—Color cinnamon; finely punctured. Head short, eyes black, round, occupying almost the entire side of the head. Thorax oblong, about three times the length of head, almost parallel with the eyes, but narrower than the elytra. Length $\frac{7}{16}$ inch. Quebec; common.

The above is unknown to Dr. LeConte. I have compared it with his *Corymbites pyrrhos*, which belongs to an allied genus, and cannot detect sufficient specific difference to separate them. The latter was pronounced by the Ent. Soc. Philad. to be *pyrrhos*, Lec.; however, I am satisfied, since Dr. LeConte has seen the insect, that the specimen was not properly determined.

5. *TELEPHORUS ARMIGER*.—Maxillæ, palpi, and front of head to base of antennæ yellow, the latter 11-jointed;—2nd joint shortest. Head black; thorax with two black elevations; lateral margin yellow—posterior angles acute; anterior and posterior margins black, slightly reflexed. Elytra black, minutely granulated, with two longitudinal ridges. Coxæ and joints of the legs yellow. Body beneath, black. Length $\frac{5}{16}$ inch. Quebec; uncommon.

The mandibles of the above are long and acute. It differs from *Telephorus* (*Cantharis*) *fraxini*, Say, (Jour. Acad. Nat. Sci., Phila., 3, 181,) in not having “confluent, slightly impressed punctures, forming irregular transverse lines.”

6. *PODABRUS SIMPLEX*.—Mouth, palpi, and front of head to base of antennæ, yellow; tips of palpi black. Posterior portion of head black, narrow where it joins the thorax. Eyes large, globular. Antennæ 11-jointed—first joint longest, second and third shortest and of equal length, the remaining five uniform and black. The two basal joints of antennæ, thorax and anterior pair of legs and coxæ yellow. Thorax almost square, longitudinally elevated on each side posteriorly. Scutellum large, triangular. Elytra black, slightly granulated, polished, with short scattered whitish hairs. Body beneath, and posterior legs black. Length $\frac{4}{16}$ inch. Quebec, June.

About twenty-five American species are known to Dr. LeConte, and I am assured by him that my species has not been heretofore described.

7. *MYCETOCHARES BICOLOR*.—Head, eyes, thorax, elytra, and the two posterior segments of abdomen, black. Antennæ, legs and anterior segments of abdomen ferruginous. Head and thorax minutely punctured, the posterior margin of the latter transverse. Elytra striate, and densely punctured in the striæ; sutural striæ abbreviated; the fourth and fifth shortest posteriorly, terminating together. Length $\frac{5}{16}$ inch. Quebec; uncommon.

This is the first of the genus found in Lower Canada. Other species may occur in the Ottawa country. Dr. LeConte says he has “four species, of which *M. binotata*, Say, is the only one described.”

8. *CISTELA QUADRISTRIATA*.—Head black. Thorax and elytra smooth, testaceous, minutely punctured, the latter having two abbreviated striæ on the posterior margins of suture. Antennæ, palpi, legs and body ferruginous. Length $\frac{4}{16}$ inch. Quebec; uncommon.

Easily identified from the double sutural striæ occurring on the posterior half of elytra.

9. *POLYDROSUS ? ELEGANS*.—Nose black; head, thorax, under part of body, lateral and sutural margins of elytra covered with white decumbent hairs. The five central ridges of elytra are covered with yellowish hair blending with the white on the shoulders. A mixture of the two colors occurs on the disc of thorax, presenting a white longitudinal line on the sides of the thorax. Legs reddish, covered with white hairs; tarsi triangular, with a single claw to each. The latter character alone will serve to determine this beautiful insect. Length $\frac{5}{16}$ inch. Quebec; rare. Dr. LeConte is not satisfied that the above is a true *Polydrosus*.

10. *GRYPIDIUS VITTATUS*.—Mouth obtuse; antennal groove forms the segment of a circle; head channeled, minutely punctured; thorax densely punctured, and parallel with the eyes. Entirely covered with short erect white and yellowish hairs, which in certain lights are richly bronzed. White longitudinal vittæ obscure on the centre, but visible on each side of the thorax, commencing behind the upper part of the eye and connecting with 5th, 6th, 7th, and posteriorly on part of the 4th and 3rd elytral ridges. The three marginal ridges are white. Elytra striate. Abdomen composed of five visible rings, the 3rd and 4th of equal width, the last equal to the 2nd. Legs ferruginous, and pubescent. Length $\frac{3}{16}$ inch. Quebec; common in fields during the summer.

11. *MICRORHOPALA INTERRUPTA*.—Black. Head, thorax and elytra densely punctured. A reddish-yellow stripe near the lateral margin of the thorax is continued on half the elytra, occupying the distance of thirteen punctures, where it terminates,—but the stripe occurs again on the same lævigated ridge, posteriorly for the length of five punctures. A yellow mark occurs at the termination of the next lævigated ridge in the region of the suture and near the apex, on the sides of which are three punctures. Length nearly $\frac{4}{16}$ inch. Taken at the Hermitage, north of Quebec; June.

The form is that of *M. Pluto*, Newman, or *M. Xerne*, Newman (?) taken in the same locality. The above species is however differently marked from either. *M. Pluto* is entirely black, and the yellow stripe on the elytra of *M. Xerne* is continued to within a short space of the apex, and occupies a distance of twenty-four punctures, while the inside mark occupies less than three.—*Read before the Quebec Branch, 5th January 1865.*

DESCRIPTION OF A NEW SPECIES OF ALYPIA.

By WILLIAM COUPER, Quebec.

ALYPIA LANGTONII.—Antennæ filiform, longer than Kirby's *A. MacCullochii*—the tips slightly bent outward, having white bands on the upper part, which can be traced for half their length; the bent part dark velvety. Palpi black, cream-colored in the centre; head and eyes black, the latter with a cream-colored stripe on their inner margin, and a small spot of the same color on the top of the head. Thorax black, margins and anterior portion underneath cream-colored. Abdomen, anterior and posterior wings indigo-black, the latter fringed. Two cream-



Alypia Langtonii, Couper; nat. size.

colored spots on the anterior wings: a semi-triangular spot runs longitudinally between the anterior and interior margins, and a larger kidney-shaped one is placed transversely opposite the posterior margin. One cream-colored semi-triangular spot on the posterior wings; the spot is straight anteriorly, and rounded posteriorly, with a faint longitudinal black line running through its anterior margin. The four anterior tibiæ are densely fringed with orange hair. Expanse of anterior wings, including thorax, $1\frac{1}{4}$ inch. Quebec; rare. [In the cabinet of the Quebec Branch Ent. Soc. of Canada.]

This beautiful insect is very distinct from *Alypia MacCullochii* (Fauna Bor. Am., page 301, plate iv, figure 5), which has "three very white spots" on the primaries, and "also three white spots" on the secondaries. The only resemblance to it is its black color, and "the four anterior legs (*tibiæ* in my species), externally covered with long orange-colored hairs, characters peculiar to the genus." In my species the apex of abdomen is acute, while in Kirby's it is obtuse. Three specimens taken in the neighborhood of Quebec did not present any variation of wing-spots. The larva is unknown to me. For further information regarding the

genus *Alypia*, see "Notes on the Family *Zygænidæ*," by A. S. Packard, jr., in the Proceedings of the Essex Institute, Salem, Mass., April 1864.

I have much pleasure in dedicating this species to John Langton, Esq., President of the Literary and Historical Society of Quebec.

MEETING OF BRITISH ASSOCIATION.

ACROSS THE ROCKY MOUNTAINS.

Mr. Markham read a paper, by Viscount Milton and Dr. Cheadle, entitled, "An Expedition Across the Rocky Mountains into British Columbia, by the Yellow Head or Leather Pass." In the Spring of 1862, Viscount Milton resolved to investigate for himself the nature of the country between the Red River Settlement and the Rocky Mountains; and to penetrate, if possible, by the shortest route, direct to the gold-regions of Cariboo; an enterprise hitherto unattempted.* He was fortunate enough to secure as his companion in this attempt, his friend Dr. Cheadle, of Cain's College, Cambridge, to whose energy and enterprise, Viscount Milton says, "the success of the enterprise is mainly to be attributed." After recording the circumstances that preceded their arrival at Edmonton, the paper continues:—

Before proceeding further with the account of our journey. I must allude very briefly to the magnificent country which extends from Red River almost to the base of the Rocky Mountains. It has been well described by Captain Palliser and Dr. Hector, and I would add my testimony to the fertility of its soil, and to the extent of its resources. It is peculiarly well adapted for settlement; rich prairies, which are ready for the plough, being interspersed with woods which would furnish timber for building and fencing. The climate is the climate of Canada; the spring, however, according to Dr. Hector, setting in a month earlier than it does on the shores of Lake Superior. Grain of all kinds grows here with the greatest

* Excepting of course by the employés of the Hudson's Bay Company. Also by a party of young men from Upper Canada, headed by a Mr. Jessup of Orillia, C. W., who crossed the continent in 1859: they followed the canoe-track to Red River, thence to Tête Jaune Cache by the plains, descending Fraser River as best they could to British Columbia.—EDS.

luxuriance, and the root-crops are certainly finer than any I have ever seen in England. The pasturage is almost endless in extent, and so nourishing that the horses turned out in the snow at the commencement of winter, and then thin and in wretched condition, when brought up in the following spring were exceedingly fat, and fit to set out at once on the journey before them. Coal-beds of large size exist on the Saskatchewan, Battle, and Pembina Rivers. Clay iron-stone in large quantities was discovered by Dr. Hector, and miners were engaged in washing gold in the river above Edmonton during our stay there. Yet this glorious country, estimated, I believe, by Dr. Hector at forty millions of acres of the richest soil, is, from its isolated position, and from the obstructions put in the way of settlement by the governing power, left utterly neglected and useless, except for the support of a few Indians, and the employés of the Hudson Bay Company. Could communication be established with Canada and British Columbia, this district would, I imagine, become one of the most valuable of the British possessions. After remaining three weeks at Fort Edmonton for rest and preparation, the travellers and their party set out on their journey across the mountains, following the trail between Lake St. Anns and Jasper House; a day's journey on the road generally consisting of continual floundering through bogs, varied by plunges and jumps over the timber lying strewn, crossed, and interlaced over the path, and on every side. Between Lake St. Anns and the foot of the mountains the forest is almost unbroken—a distance of nearly three hundred miles. After the lapse of twenty-six days from leaving Fort Edmonton, the travellers found themselves fairly in the Rocky Mountains. They followed the course of the Athabasca for some time, but afterwards followed the valley of the Myette, and eventually reached the height of land so gradually that they would hardly believe they had gained the water-shed of the Pacific. A few days after, they struck the Fraser River, already a stream of considerable size. From this point up to the almost perpendicular sides of the narrow valley in which we were shut in, this portion of our journey was the most harassing we had yet experienced. The path lay almost entirely through water up to the horse's girths, the only change being to swamps, embarrassed with fallen timber of very large size. When we reached Moose Lake, an expansion of the Fraser, about fifteen miles long, and two or three wide, our difficulties increased. The trail along the beach

was now under water, and we were frequently obliged to ascend the steep mountain-side, when the accumulations of drift-wood barred the passage along the shore. Numerous mishaps occurred, the horses perversely going out into deep water, and floating about, to the great detriment of flour and pemmican. Two rolled down the mountain side, and had to be unpacked, and their loads carried up to enable them to re-ascend. We found no place to rest during the day; and when night came on we had not reached the end of the lake, and were obliged to camp in a bare sandpit, without any feeding-ground for our weary animals, who ranged restlessly to and fro until the morning. The road continued almost as difficult all along the valley of the Fraser, and at one point was a narrow ledge of a few inches along the face of a cliff of crumbling slate, rising perpendicularly a tremendous height above us, and a steep descent of above two hundred feet to the river below. On the fourteenth we crossed a great number of small streams, many probably mouths of the Moose River, an important tributary of the Fraser flowing from the north. This grand fork of the Fraser is at the foot of a very high mountain, which has received the name of Robson's Peak (and is the original Tête Jaune Cache), so named from being the spot chosen by us. After journeying thus, meeting greater difficulties still, the travellers left the Cache and kept the emigrants' trail, which they followed into the dense forests until it came to an end at a place where there had been two large camps, and where, from all they saw about them, they concluded that the whole band of emigrants had given up in despair the idea of cutting through forests so dense and encumbered, and had built large rafts, in order to drop down the river to Kamloops. This plan our travellers had no means of following, and after difficulties and disasters which the paper describes, they at length managed again to come on a trail, and were soon after encouraged by hearing a crow, a sure sign of more open country, and eventually they reached Kamloops. The paper concludes as follows :—

In conclusion, I must venture a few general observations upon the nature of the country through which we passed, from Fort Edmonton, on the eastern side, to Kamloops on the west of the mountains, with regard to the practicability of a road or a railway being taken across by that point. Our party being, I believe, the only one which has passed through this region entirely by land, the testimony has some value, as being all that is known of a very considerable portion of the distance. In the first place, I may

safely state, that, with the exception of one or two rocky and precipitous bluffs,—few and trifling obstructions, compared with those which have been already so successfully overcome in making the road along the Fraser River,—there are no engineering difficulties of any importance. On the other hand, however, for almost the whole distance, the road would require to be *made*, there being no open country until reaching the lower portion of the valley of the North Thompson. From Edmonton to Jasper House the surface is slightly undulating; and the lower ground universally swampy, even where covered with thick forest. From Jasper House to Tête Jaune Cache, the pass through the main ridge of the Rocky Mountains, the valley is, for the most part, wide and unobstructed, except by timber, which is generally of large size; the rivers small and mostly fordable, even at their highest. The ascent to the height of land is very gradual, and, indeed, almost imperceptible; and the descent, although much more rapid, neither steep nor difficult. From the Cache to the first opening out of the valley of the Thompson, about eighty miles north of Kamloops, the only route lies along that river, running through a succession of narrow gorges shut in on each side by lofty and inaccessible mountains. The whole of this portion is obstructed by growing and fallen timber of the largest size; but the fact of our being able to bring horses through without any previous track being cut open, proves sufficiently that there are no serious obstacles in the way of an engineer. No great ascents or descents occur, the bottom of the ravine being generally level, except where the transverse ranges of hills come down close to the water's edge. Many of these are, indeed, rocky, but consist generally of broken fragments of no great size. No bluffs of solid rock appear until the last forty miles, where the country is generally open, and otherwise little obstructed. The flooding of the river by the melted snows of the mountains does not interfere with the passage along the valley, we having traversed it in the middle of the summer when the waters were at the highest. A road might possibly be made more direct to Cariboo than by continuing on to Kamloops, by following the north-west branch of the North River, which comes in about sixty miles south of Tête Jaune Cache, or the Canoe River, some fifteen miles below that place; but, from the rugged nature of the country to the west, such a road could only be made by great labor and outlay. The easiest line would, I apprehend, be from the junction of a small river which flows into the Thompson, about

twenty miles north of the Clearwater, or about eighty north of Kamloops. This stream, the Indians informed us, came from the Cariboo Lake, and passes through a totally open region. The most serious difficulty to the adoption of a route by Jasper House would be the want of pasturage for cattle. The patches of open country are few on the eastern side, rather larger and more numerous within the mountains; but after leaving the Cache, on the western side, the forest is unbroken for above a hundred miles, and in no portion of the whole six hundred or seven hundred miles from Edmonton to the Clearwater, except at Jasper House, is there sufficient food for any large number of animals. The advantages of this route would be—1st. That it lies far removed from the boundary-line, well within British territory. 2nd. That it passes entirely through a country inhabited only by friendly and peaceable Indians. 3rd. That it offers the most direct communication from Canada to the gold-regions of British Columbia; and from it the Sewshwap and Okanagan districts, as well as the road on the Fraser, are easily accessible. These considerations are, I think, of sufficient importance to require that the question whether this more northern pass does not, from its directness and the security which it offers, possess more solid advantages than those lying further south, should be carefully and fairly weighed. The more southern passes lying within the British line are far more steep and difficult than the one by Jasper House, and are in unsafe proximity to the United States territories. The only advantages to be claimed for them appear to be that they communicate with more open country on either side, that pasturage is plentiful along the road, and that, from their more southerly latitude, they are likely to be blocked with snow for a shorter period. But whichever be the one selected, I would urge most strongly the necessity for immediate action in the matter, and hope, though not with confidence, that the New Hudson Bay Company will cast off the prejudices and lay aside the obstructiveness which degraded the policy of the old one, and promote, to the utmost of their power, that scheme, which is of such vital importance to the advancement of all the British possessions in North America.

The President spoke highly of the value and interest of the paper, and eulogised the conduct of Viscount Milton in leaving the ease and luxury of a home like his for the true advancement of science. He had more successfully than any other traveller, faced the dangers and difficulties of a most difficult and inaccessible country.

Dr. Cheadle, in the course of some supplementary remarks, said that throughout British Columbia, except a few isolated portions, no farming-land was to be found. Though it was possible by irrigation to produce certain crops in a few years, yet they must soon cease, for there was nothing but sand, the only vegetable mould being supplied by the decay of grass. In most parts the land was so light that it was impossible to irrigate it. But this country, so rich in minerals, was only separated by the Rocky Mountains from the rich and productive country on the other side, showing the necessity for opening-up a communication between them.

Lord Milton, in the course of a few observations, expressed his great obligations to Dr. Cheadle, and said that the Red River Settlement was the best colony England had for farming purposes, but nowhere was farming less understood. One man there, after sowing eleven crops of wheat in succession on the same land, began to inquire the reason why his crops had failed. This showed at once the richness of the soil, and the ignorance of many who cultivated it.

The President said, so convinced was he of the value of the paper that had been read, that he should claim on the part of the Royal Geographical Society, that it should be placed upon the permanent records of the Association.

REVIEWS.

PROCEEDINGS OF THE PORTLAND (MAINE) SOCIETY OF NATURAL HISTORY.—We have received with pleasure the first number of the Journal and of the Proceedings of the Portland Society of Natural History.

The Journal is occupied by one of the most elaborate papers we ever remember to have seen on such a subject, on the terrestrial Pulmonifera of the State. Too much praise can hardly be given to the patient manner in which the microscopic details of the species have been worked out. Careful drawings are given of the buccal plates and lingual ribbons of nearly all the molluscs described, and of other interesting peculiarities whether in the animal or in its shell. The nomenclature of all the species is utterly changed, and Mr. Morse divides the twenty-six Helices of the State into four sub-

families! We are not disposed to agree with our author in considering the American varieties of *Helix pulchella* and *H. chersina* and *Zua lubrica* as sufficiently distinct from the European types.

The first paper in the Proceedings is a catalogue of the flowering plants of Maine, by G. L. Goodale. The list appears to have been prepared with great care, is very complete, and is evidently the work of a sound critical botanist. To this succeed catalogues of the mammalia and birds of the State, which we have no doubt will prove interesting to the student of Zoology in Canada. Most of the mammals of Maine are also well known to inhabit this colony, but as yet very little critical attention seems to have been paid to the higher animals in Canada. The following Maine species, so far as we know, have not yet been recorded, at any rate as inhabiting Lower Canada, and have probably been overlooked:

Vespertilio Carolinensis, Geoffroy (common brown rat). *Sorex Forsteri*, Rich. (Forster's shrew). *Sorex Richardsonii*, Bach. (Richardson's shrew). *Sorex platyrhinus*, Wagner (Eared shrew). *Sorex Thompsoni*, Baird (Thompson's shrew). *Blarina brevicauda*, Gray (Short-tailed mole shrew). *Vulpes Virginianus*, Rich. (Grey fox). *Putorius Richardsonii*, Bonaparte (Little ermine). *Putorius nigrescens*, Aud. and Bach. (Little black mink). *Hesperomys leucopus*, Wagner (White-footed mouse). *Hesperomys myoides*, Baird (Hamster mouse).

Prof. Hitchcock gives a careful and detailed description of the Devonian and Upper Silurian rocks of part of the State. Three new species of Devonian plants are described by Principal Dawson, from the 'plant-bed' at Perry. The State geologist then gives localities for various interesting fossils, calls attention to a peculiar arrangement of boulders near Bethel, and lastly gives an account of the post-tertiary clays of Maine, and compares the fossils which they contain with the lists (published in the *Can. Nat.*) of the organisms procured from the drift of the St. Lawrence valley. A large proportion of the marine invertebrates are common to the post-pliocene deposits of Maine and Canada East; and where differences exist, it appears to us that they are very similar in character to those which obtain in the existing fauna of the two coasts. Dr. Fogg's "List of the Reptiles and Amphibians found in Maine" has also its special interest to Canadian naturalists. We know but little of the geographical distribution of these creatures in Canada, much less even than of the mammals. Of the eleven species of snakes found in Maine, we have determined eight of the species as

also inhabiting Lower Canada. Of the turtle family, all the Maine species have been detected in Canada East, with the exception of the mud-turtle (*Ozotheca odorata*, Ag.) and the box-turtle (*Cistudo Virginica*, Ag.). The newts and lizards have been very little explored: eleven species are known in Maine, and at present but five in the neighborhood of Montreal. Dr. Dawson describes some new plants from the Upper Devonian of the vicinity of the Perry River, in addition to those already alluded to. These fossils bear a striking resemblance to the plants of the coal-period, and most of the genera, *e. g.* Stigmaria, Calamites, Dadoxylon, Cordaites, Sphenopteris, and Hymenophyllites, range upwards into that formation. The student of the fossils of the Quebec group and of the Lower Silurian rocks generally in Canada, will find Prof. Hitchcock's paper on the fossils of the Potsdam group well worthy of perusal. Lastly, Mr. Billings contributes an important article on Silurian and Devonian fossils from various parts of Maine. He describes and illustrates several new species of shells (principally brachiopods), also seven new trilobites.

This journal, judging from the first numbers, bids fair to rank high among the scientific periodicals of the United States, and clearly proves that the study of Natural History in Maine has not been neglected. The illustrations are artistic, and the numbers on the whole are well got up.

J. F. W.

ICONES MUSCORUM, OR FIGURES AND DESCRIPTIONS OF MOST OF THOSE MOSSES PECULIAR TO EASTERN NORTH AMERICA WHICH HAVE NOT BEEN HERETOFORE FIGURED; BY WILLIAM S. SULLIVANT, LL.D., etc., etc. With one hundred and twenty-nine copper-plates. Cambridge, Mass. 1864.: Sever & Francis. London: Trubner & Co. Imp. 8vo.—This book, by a corresponding member of our Society, and one of the ablest living Bryologists, is thus noticed by Prof. Gray in the November number of Silliman's Journal: "We briefly announced this work in the September number of this Journal, in terms of unqualified admiration—which were intended to apply as well to the scientific character of the volume as to the rare perfection of the typography and the plates. One hundred and thirty species are illustrated, a full plate (with one or two exceptions), and commonly two pages of letter-press, being devoted to each. The detailed descriptions are in Latin, as also the explanation of the plates; the habitat and the general remarks are in English. The

plates represent the Moss of the natural size, as magnified, and with an ample series of exquisite analyses; for the most part there are as many as twenty figures to each plate. The drawings are placed to the credit of Mr. August Schrader, who has had a long training for such work under Mr. Sullivant's direction. They were engraved by Mr. Wm. Dougal, of Washington, who executed the plates of *Musci* of Wilke's Pacific Expedition. Probably upon no work of the kind has an equal amount of labor, knowledge, and expense been lavished. Only a small edition has been printed, and it is published at a price (\$10 in gold) which, however considerable at present, will, it is understood, be very far from covering the cost."

NATURAL HISTORY SOCIETY.

The ordinary monthly meeting of the Society took place on Monday evening, Jan. 30, and was fairly attended. It was determined that the Society's annual *Conversazione* should take place towards the latter end of February, and a committee was appointed to make the necessary arrangements. Various donations were announced, the following being the more important:

TO THE MUSEUM.

Specimen of the mottled owl (*Scops asio*, Bonaparte), from Mr. W. Boa; the Cape-May warbler (*Dendroica tigrina*, Baird), from Mr. P. Kutzinger; twenty-three species of beetles (named), from Washington, South Carolina, and California, from Mr. W. Couper, Quebec; fine crystal of amethyst, from the north shore of Lake Superior, presented by the Literary and Historical Society, Quebec; specimen of Cooper's hawk (*Accipiter Cooperii*, Bonaparte), and thirty species of Canadian insects, from Mr. W. Hunter.

NEW MEMBERS.

Messrs. D. R. McCord and T. Reynolds were elected members of the Society.

PROCEEDINGS.

Mr. D. R. McCord read a paper on the well-known Canadian fern, *Cystopteris bulbifera* of Swartz. This little "bladder fern" has the peculiarity of bearing small bulbs, usually near the angles formed by the junction of the mid-rib of the frond, and those of some of the pinnæ. The microscopic character of these

bulbs was shown in detail, and was illustrated by careful drawings on the black-board. The peculiarities of their germination were also elaborately explained. The author of the paper stated, that, after careful microscopic investigation into the fructification of ferns, he was inclined to think that the views usually promulgated with regard to the impregnation of these plants were untenable. Considerable discussion followed after the reading of this paper, in which the Right Rev. the Lord Bishop, Mr. Barnston, and Dr. Dawson took part. Dr. Dawson stated that this little fern, like many flowering plants, appeared to have two distinct means of propagation. The spores of course were the strict analogues of seeds, while the bulbs appeared to be undeveloped buds, in which phenomena took place similar to the ordinary budding-process.

A paper by Mr. R. J. Fowler "On Shells taken from the Stomachs of Flounders," was next read by the Recording Secretary. It is, and has long been, well known that many fishes—such as the cod, and many of the flat fishes—often feed upon marine shells; and many rare deep-water molluscs have only been procured from the stomachs of fishes. In the winters of 1861-62 and 1862-63, very large flounders (said to have been taken at Portland, Maine, U. S.) were sent to the Montreal markets, frozen and uncleaned. The stomachs of nearly all these contained marine shells, often of considerable size. During two winters, about thirty or forty species were procured from this source, some of considerable rarity, and these sometimes in great numbers. About 100 magnificent specimens of the rare *Yoldia thraciæformis* (a large sub-arctic bivalve shell) were taken, and two specimens of another bivalve (a species of *Neœra*) which has never before been taken on the North American coast. This last shell is probably identical with a rare British species, occasionally taken at Loch Fyne and a few other Scottish localities.

Dr. Dawson then exhibited and made some remarks upon a collection of fifty-seven species of plants made in Newfoundland in the autumn of 1864, at the instance of Mr. A. Murray, of the Geological Survey of that Island. Amongst the most interesting plants collected we notice *Calluna vulgaris* (see this journal, 1864, page 459), *Lychnis alpina*, *Hedysarum boreale* (which occurs also on the mountains of Vermont and on the Alleghanies), *Epilobium latifolium*, *Cornus suecica* (found also in Norway), *Aster graminifolius* (a White Mountain species), *Gentiana acuta*, and *Pleurogyne rotata*. A remarkable variety of

the common harebell or bluebell of Great Britain, which was known to occur about Lakes Huron and Superior, and which, by some, has been elevated into the rank of a species, under the name of *Campanula linifolia*, has been also found in Newfoundland. Its very limited distribution in North America is quite remarkable. Dr. Dawson remarked that the plants of Newfoundland appear to be of a boreal or sub-arctic type, that the flora was of a decidedly Scandinavian character, and that many of the species were identical with plants found in Great Britain and in various other parts of Northern Europe.

J. F. W.

ANNUAL CONVERSAZIONE.

The third annual Conversazione of the Society was held at the rooms, University Street, on the evening of Monday, Feb. 21st, on which occasion the museum and library were thrown open, and crowded by a concourse of our most respectable and influential citizens, a large number of ladies being present. In the library were a number of microscopes of great power, exhibited by Messrs A. S. Ritchie and F. Cundill, which attracted a constant succession of the curious, many of the specimens being deeply interesting. In the lecture-room were laid out a number of illustrations and illustrated works, in connection with various departments of Natural History; Mr. D. R. McCord's collection of Canadian Ferns; a series of De La Rue's photographs of the Moon; and microscopes exhibited by Messrs. J. Ferrier, jun., and Thomas Rimmer. The visitors having entertained themselves with inspecting the various objects of interest, or in listening to the fine strains of the band of the 63rd Regiment, stationed in the gallery of the museum, finally assembled in the lecture-room, to listen to an address from Principal Dawson.

PRINCIPAL DAWSON said that although the members of the Natural History Society were not a speaking people, he desired to say a word on what they aimed to accomplish, as well as on the various objects exhibited that evening. The object of the Society was three-fold: first, industrial or economic; second, educational; and third, scientific, which might be termed their object proper. In the economic department, their aim was to collect objects illustrating the products of the country, as well as to diffuse information as to anything in relation thereto which had an injurious tendency: he believed they had already done something in this way. Their educational object was to diffuse among young people a taste for something more than ordinary light or frivolous

pursuits, and for this purpose they had collected a number of objects illustrative of various departments in natural history, and endeavored to create an interest in such studies by popular free-lectures, which, he trusted, would do something to diffuse a taste for such pursuits. In years gone by they had done something in this direction; but of late their means and appliances had been much improved, which was due in a great measure to the care and exertion of Mr. Whiteaves. The objects in the Society's Museum generally, had been better arranged; and any person by looking over the collection might obtain a considerable amount of information. Lastly, in regard to the scientific department, he must observe it was less popular; they had, nevertheless, been trying to make original discoveries in geology and other branches. These had been discussed in their journal and at their monthly meetings, as most people who knew anything of the Society's proceedings were aware. By means of the journal, too, information had been diffused in other countries as to what was doing here. In all these ways they had been trying to advance the cause, and they invited those present here this evening, in order that they might take an interest in the Society, and give it such countenance and support as they were able, this being the principal object of the entertainment. In regard to the objects exhibited, an illustration would be given of the electric telegraph; as well as of the fire-alarm telegraph, which he hoped would alarm no one. Dr. Smallwood had also swung a long pendulum by which he intended to show that the earth still moves, and spins round with all its weight of civilization as merrily as ever. Upon the table in front of the platform was an ancient Canadian fossil (the *Eozoon Canadense*), an example of the humble organic structure which ushered the dawn of life into the world; and beside it was the cast of a skull found in a cave in Belgium with the bones of extinct species of mammoths, with which it was believed to be contemporaneous. The old gentleman in question might have dined with Methuselah; and some thought that he might even have existed before Adam,—which, however, he (Dr. Dawson) did not believe. It was an ordinary long-headed skull of the Celtic type. A number of persons had also contributed microscopes with many objects not easy of collection. Mr. McCord had exhibited his collection of Canadian Ferns; and a series of water-color drawings of Canadian Fishes had been received from Mr. Fowler, who, it was hoped, would continue his labors in this direction. Behind him were a number of photo-

graphs of the moon, which we were apt to believe a spotless orb, but we were surprised to find her face full of blemishes presenting an appearance somewhat like an ancient cinder, instead of the poetical attributes usually attributed to her. These were a few of the objects before them, of which it was desirable those present should avail themselves, and he trusted the result would be that many would connect themselves with the Society. In conclusion, he would state that the Sommerville lectures, and the scientific monthly meetings, were all open to ladies, and, as he knew many of them were given to the study of scientific subjects, they would be glad to have them present on these occasions. He hoped that all would separate mutually satisfied with the instruction they had received; and Dr. Smallwood would now proceed to show them his little experiment relative to the rotation of the earth.

Dr. Smallwood now proceeded to explain by means of a large pendulum suspended from the ceiling, the experiment alluded to; tracing in some remarks, the history of the discovery of the earth's motion from the time of Galileo, and was listened to by those present with much attention.

The numerous visitors, having amused and instructed themselves with the various objects provided for their entertainment, gradually dispersed; carrying with them, there is little doubt, a greater interest in the welfare of the Society.—*Newspaper Report.*

MONTHLY MEETING.

The ordinary meeting of the Society was held on Monday evening, March 6th, the President, Principal Dawson, in the chair.

Among the more important donations to the Museum and Library during the past month are the following:—

TO THE MUSEUM.

The Arctic puffin (*Mormon Arctica*, Linn.), and the gannet (*Sula bassana*, Linn.), both from the Lower St. Lawrence; presented by Mr. Pierre Fortin.

Fine specimen of the rare cinereous owl (*Syrnium cinereum*, Baird), shot on the Island of Montreal; from Mr. Alex. S. Ritchie.

Twenty-one species of fossils from the Carboniferous Limestone of Ireland and Nova Scotia; presented by Principal Dawson.

TO THE LIBRARY.

Embryology of the starfish, by Alex. Agassiz; from the author.

PROCEEDINGS.

Mr. A. S. Ritchie then read a paper "On the structure of Insects." He commenced with a sketch of the history of Entomology from the time of Linnæus and still earlier authors, down to the present day. He then briefly reviewed the methods of classifying insects which have been suggested by different authors; some of whom founded their systems on the more or less perfect changes which insects undergo, others on the peculiarities of the structure of the wings, or of the other organs of locomotion, some on the mouth and the organs surrounding it, and so on. An account was given of a few of the insects which are regarded with superstitious dread by the ignorant, as the death-watch and the death's-head moth. Attention was then called to the enormous numbers of insects which are known to science, the number of species being estimated at somewhere near 300,000. The microscopical anatomy of these creatures was dwelt upon in minute detail. The tracheæ or air-tubes were first described: these run the whole length of the body, and branch off to every part, the tubes being kept expanded by an elastic spiral filament, somewhat like the spiral vessels in plants. These tubes have outlets along the sides of the thorax and abdomen, called spiracles, which are usually fringed with hairs to prevent impurities passing into the delicate breathing-apparatus. The structure of the antennæ of various kinds of insects was then explained. They seem to be organs of sensation, touch, and perhaps of hearing. The compound-facettèd character of the eye in insects was next dwelt upon. These facets are often very numerous: in the ant they are said to amount to fifty, in the house-fly they number 4,000, in the dragon-fly 12,000, and, according to Geoffroy, the eye of a butterfly contains upwards of 34,000 lenses. The various parts of the mouth were then detailed, and after these the peculiar arrangement of the legs and feet in various insects. Having described the various organs of insects in the abstract, the lecturer proceeded to illustrate how they varied in different kinds of insects. From the beetles three species were selected—the *Cicindela campestris*, a carnivorous ground-beetle; the *Dyticus marginalis*, a large aquatic species; and the *Melolontha vulgaris*, more commonly known as the cockchafer. The sharp scythe-like jaws of the tiger-beetle were described, also its large prominent eyes; its predatory habits were dwelt on at some length, also the habits of the larva. The boat-like shape of the *Dyticus*, and its oar-like feet, and various other organs, were next considered. Like

the Cicindela, it is predacious in its habits, and has been known to devour fishes and frogs far larger than itself. The cockchafer is purely vegetarian in its habits; its mouth seems more adapted for grinding its food, than cutting it, and its sluggish shape contrasts strongly with that of some of the carnivorous ground-beetles. It is said that poisons have no effect upon the grub of this beetle, but alkalies seem fatal to it. Further examples were then taken from the order to which the locusts and crickets belong. The various peculiarities of the house-cricket were described, particularly its remarkable gizzard, covered internally with scales or horny points. The mechanism by which the chirrup of the grasshopper is effected, was explained at considerable length, as were also various points of structure in the mole-cricket and the cockroach. The dragon-fly and the *Urocerus gigas*, an insect very destructive to pine-trees, were also described in detail, particularly the curious ovipositor of the latter; and the last illustration selected was one of the saw-flies. The lecturer concluded by remarking that all these curious contrivances were evidently made to adapt each insect for its special functions in the economy of nature, and that it afforded one of the many proofs of the harmonies to be observed in the material world. The paper was illustrated with a number of microscopical preparations of various parts of insects, and with a large series of magnified drawings.

After some remarks upon the paper by Principal Dawson, by the Right Rev. the Lord Bishop, the Rev. A. F. Kemp and others, the thanks of the meeting were voted to Mr. Ritchie for his paper.

J. F. W.

Mr. Watt presented to the meeting:—

1. A very full catalogue of Canadian plants, by Mr. A. T. Drummond of London, C. W., including not only that gentleman's own collections throughout the Province, but also a reference to nearly all that has been published on Canadian Botany. His list of Lichens is particularly full, embracing about 150 species.

2. An elaborate catalogue of the Flora of the county of Hastings, C. W., by Mr. Macoun of Belleville, which includes many rare and interesting plants. Mr. M.'s list of Carices is especially interesting, and extends to nearly ninety species. His list of mosses includes one very interesting new species,—*Neckera Macounii*, Sullivant, MS. Canadian Muscology offers an inviting field for assiduous exploration.

3. A catalogue of the collections of Dr. J. G. Thomas, in the vicinity of Quebec and of Rivière-du-Loup, C. E. Credit is due

to this botanist for having been the first to observe the true *Woodsia alpina* in Canada, a specimen of which in good fruiting condition was exhibited. The plant found by Mr. Bell in Gaspé, and referred by Dr. Lawson to *W. glabella* (see this Journal, 1864, page 288), and by Prof. Eaton to *W. alpina* (ditto, page 4), appears to have been immature, and consequently difficult of determination. Dr. T. has also found the normal *W. glabella*, and his station (the upper falls of the Rivière-du-Loup) is the only thoroughly reliable Canadian one known to us for that rare variety. A specimen of the *Botrychium Lunaria* of Swartz of unusual size and in a perfect fruiting state, found by Dr. T. at Rivière-du-Loup, was also shown. This fern proves to be general throughout Canada;—its apparent rarity may be accounted for by its inconspicuous mode of growth.

Dr. Thomas says (in a letter to the Editor), "The flora of this interesting region (Rivière-du-Loup) is semi-arctic, the plants of Labrador and thence northward being found along with natives of central Canada. Among the Gentianaceæ we have *Pleurogyne rotata* (a decidedly Labrador plant) and *Gentiana acuta* (Michaux), growing almost side by side with *Halenia deflexa* and other gentians of lower latitudes. * * * * Around Quebec, the hay-fields are white during summer with the flowers of the common ox-eye daisy (*Leucanthemum vulgare*, Lam.); but below Quebec it gradually becomes scarcer, until at L'Islet it stops, and is not seen below. The plant is introduced enough, as nearly all the hay-seed sown by the farmers is brought from Quebec. The corn-cockle (*Agrostemma Githago*, L., usually a too common weed) is extremely rare here. I have found no representations of the Goose-foot family (Chenopodiaceæ), which is remarkable. Our specimens of *Saxifraga aizoon* are peculiar. The scape (or rather stem in this case) is decidedly leafy; the leaves are alternate, and resemble those clustered at the root, which are thick, spatulate, and sessile, with cartilaginous margins, and are slightly smaller than the radicle leaves. Among the Scrophulariaceæ, I collected *Veronica Chamædrys*, L., at Lévis in 1859 (where it is not common), with its leaves decidedly petioled, and not sessile as in the British plant; the petiole is not long—about $\frac{1}{3}$ to $\frac{1}{16}$ of an inch, but still a petiole." W.

THE CANADIAN NATURALIST.

SECOND SERIES.

NOTES ON POST-PLIOCENE DEPOSITS AT RIVIERE- DU-LOUP AND TADOUSSAC.

By J. W. DAWSON, LL.D., F.R.S., F.G.S., Principal of McGill College.

In looking over, last winter, some of the collections made by Prof. Bell, of Kingston, when engaged in the service of the Geological Survey of Canada, I was struck with a small collection of Post-pliocene shells from Rivière-du-Loup,* as presenting a somewhat singular grouping of species; and having a few holiday weeks to spend at Cacouna, I determined to ransack thoroughly the deposits which had afforded these specimens.

The country around Cacouna and Rivière-du-Loup rests on the shales, sandstones, and conglomerates of the *Quebec group* of Sir W. E. Logan. As these rocks vary much in hardness, and are also highly inclined and much disturbed, the denudation to which they have been subjected has caused them to present a somewhat uneven surface. They form long ridges running nearly parallel to the coast, or north-east and south-west, with intervening longitudinal valleys excavated in the softer beds. One of these ridges forms the long reef off Cacouna, which is bare only at low tide; another, running close to the shore, supports the village of Cacouna; another forms the point which is terminated by the pier; a fourth rises into Mount Pilote; and a fifth stretches behind the town of Rivière-du-Loup.

* See Geology of Canada, p. 921, where, however, only a portion of the species collected are mentioned.

The depressions between these ridges are occupied with Post-pliocene deposits, not so regular and uniform in their arrangement as the corresponding beds in the great plains higher up the St. Lawrence, but still presenting a more or less definite order of succession. The oldest member of the deposit is a tough boulder-clay, its cement formed of gray or reddish mud derived from the waste of the shales of the Quebec group, and the stones and boulders with which it is filled partly derived from the harder members of that group, and partly from the Laurentian hills on the opposite or northern side of the river, here more than twenty miles distant. The thickness of this boulder-clay is, no doubt, very variable, and could not be ascertained in the neighborhood of Cacouna; but at Ile Verte it forms a terrace fifty feet in height.

Above the boulder-clay, where it has not been bared by denudation, there occurs a dark gray, soft, sandy clay, containing numerous boulders, and above this several feet of stratified sandy clay without boulders; while on the sides of the ridges, and at some places near the present shore, there are beds and terraces of sand and gravel, constituting old shingle beaches apparently much more recent than the other deposits.

All these deposits are more or less fossiliferous. The lower boulder-clay contains large and fine specimens of *Leda truncata* and other deep-water and mud-dwelling shells, with the valves attached. The upper boulder-clay is remarkably rich in shells of numerous species; and its stones are covered with Polyzoa and great Acorn-shells (*Balanus Hameri*), sometimes two inches in diameter and three inches high. The stratified gravel holds a few littoral and sub-littoral shells, which also occur in some places in the more recent gravel. On the surface of some of the terraces are considerable deposits of large shells of *Mya truncata*; but these are modern, and are the 'kitchen-middens' of the Indians, who in former times encamped here.

Numbers of Post-pliocene shells may be picked up along the shores of the two little bays between Cacouna and Rivière-du-Loup; but I found the most prolific locality to be on the banks of a little stream called the Petite Rivière-du-Loup, which runs between the ridge behind Cacouna and that of Mount Pilote, and empties into the bay between Rivière-du-Loup and the pier. In these localities I collected eighty-four species, about thirty-six of them not previously published as occurring in the Post-pliocene of Canada. A list of these fossils is appended to this paper; and

in connection with it I would desire to make some general remarks on the features of these interesting deposits.

We have here an indubitable instance of a marine boulder-clay. I have observed fossiliferous boulder-clays at Murray Bay, St. Nicholas, and Cape Elizabeth, but the example afforded at Cacouna and its vicinity is more clear and instructive; and there is also evidence that the surface under the boulder-clay is polished and striated, the direction of the striæ being north-east and south-west, or that of the St. Lawrence valley.*

The Cacouna boulder-clay is a deep-water deposit. Its most abundant shells are *Leda truncata*, *Nucula tenuis*, and *Tellina proxima*, and these are imbedded in the clay with the valves closed, and in as perfect condition as if the animals still inhabited them. At the time when they lived, the Cacouna ridges must have been reefs in a deep sea. Even Mount Pilote has huge Laurentian boulders high up on its sides, in evidence of this. The shales of the Quebec group rocks were being wasted by the waves and currents; and while there is evidence that much of the fine mud worn from them was drifted far to the south-west to form the clays of the Canadian plains, other portions were deposited between the ridges, along with boulders dropped from the ice which drifted from the Laurentian shore to the north. The process was slow and quiet; so much so that in its later stages many of the boulders became encrusted with the calcareous cells of marine animals before they became buried in the clay. No other explanation can, I believe, be given of this deposit; and it presents a clear and convincing illustration, applicable to wide areas in Eastern America, of the mode of deposit of the boulder-clay.

A similar process, though probably on a much smaller scale, is now going on in the Gulf. Admiral Bayfield has well illustrated the fact that the ice now raises, and drops in new places, multitudes of boulders, and I have noticed the frequent occurrence of this at present on the coast of Nova Scotia. At Cacouna itself, there is, on some parts of the shore, a band of large Laurentian boulders between half tide and low-water mark, which are moved more or less by the ice every winter, so that the tracks cleared by the people for launching their boats and building their fishing-weirs, are in a few years filled up. Wherever such boulders are dropped on banks of clay in process of accumulation, a species of

* South 55° west mag., near Cacouna.

boulder-clay, similar to that now seen on the land, must result. At present such materials are deposited under the influence of tidal currents, running alternately in opposite directions; but in the older boulder-clay period, the current was probably a steady one from the north-east, and comparatively little affected by the tides.

The boulder-clay of Cacouna and Rivière-du-Loup, being at a lower level and nearer the coast than that found higher up the St. Lawrence valley, is probably newer. It may have been deposited after the beds of boulder-clay at Montreal had emerged. That it is thus more recent, is farther shown by its shells, which are, on the whole, a more modern assemblage than those of the Leda clay of Montreal. In fossils, as well as in elevation, these beds more nearly resemble those on the coast of Maine. It would thus appear that the boulder-clay is not a continuous sheet or stratum, but that its different portions were formed at different times, during the submergence and elevation of the country; and it must have been during the latter process that the greater part of the deposits now under consideration were formed.

The assemblage of shells at Rivière-du-Loup is, in almost every particular, that of the modern Gulf of St. Lawrence, more especially on its northern coast. The principal difference is the prevalence of *Leda truncata* in the lower part of the deposit. This shell, still living in Arctic America, has not yet occurred in the Gulf of St. Lawrence, but is distributed throughout the lower part of the Post-pliocene deposits in the whole of Lower Canada and New England, and appears in great numbers at Rivière-du-Loup, not only in the ordinary form, but in the shortened and depauperated varieties which have been named by Reeve *L. siliqua* and *L. sulcifera*.

Of *Astarte Laurentiana*, supposed to be extinct, and which occurs so abundantly in the Post-pliocene at Montreal, only one valve was found, and its place is supplied by the allied but apparently distinct species, *A. compressa*, which is still abundant at Gaspé and Labrador, and on the coast of Nova Scotia. This exchange of *A. Laurentiana* for *A. compressa* is on these coasts an unfailling evidence of less antiquity.

A study of the varietal forms under which common species occur, also leads to the same conclusion as to the less comparative antiquity of these beds; but this is a very curious and intricate question, on which I have accumulated a great number of facts which I propose to publish at a future time.

It must be observed that though the clays at Rivière-du-Loup are more recent than those of Montreal, they are still of considerable antiquity. They must have been deposited in water perhaps fifty fathoms deep, and the bottom must have been raised from that depth to its present level; and in the meantime the high cliffs now fronting the coast must have been cut out of the rocks of the Quebec group.

The order of succession and characteristic fossils seen on the banks of the Petite Rivière-du-Loup may be stated as follows, in descending order:

1. Gravel seen on sides and tops of ridges.
2. Stratified sand and clay—*Buccinum undatum* and *Tellina Grænlandica*.
3. Bluish sandy clay, stones, and boulders. *Balanus Hameri*, *Rhynchonella psittacea*, *Pecten Islandicus*, *Leda tenuisulcata*, *L. minuta*, *Tellina calcarea*, *Astarte compressa*, *Saxicava rugosa*, *Acmoea cæca*, *Scalaria Grænlandica*, *Natica clausa*, *Buccinum scalariforme*, *Bryozoa* on stones, *Foraminifera*, &c., &c.
4. Stiff reddish clay with stones and boulders—*Leda truncata*, *L. limatula*, *Nucula tenuis*, *Tellina calcarea*, &c.

At Tadoussac, opposite to Cacouna, where the underlying formation is the Laurentian gneiss, the Post-pliocene beds attain to great thickness, but are of simple structure and slightly fossiliferous. The principal part is a stratified sandy clay with few boulders, except in places near the ridges of Laurentian rocks. This forms high banks eastward of Tadoussac. It contains a few shells of *Tellina Grænlandica* and *Leda truncata*. It resembles No. 2 of the above sectional list, and has also much of the aspect of the Leda clay, as developed in the valley of the Ottawa. On this clay there rest in places thick beds of yellow sand and gravel.

At Tadoussac these deposits have been cut into a succession of terraces which are well seen near the hotel and old church. The lowest, near the shore, is about ten feet high; the second, on which the hotel stands, is forty feet; the third is 120 to 150 feet in height, and is uneven at top. The highest, which consists of sand and gravel, is about 250 feet in height. Above this the country inland consists of bare Laurentian rocks. These terraces have been cut out of deposits, once more extensive, in the process of elevation of the land; and the present flats off the mouth of the Saguenay, would form a similar terrace as wide as any of the

others, if the country were to experience another elevatory movement. On the third terrace I observed a few large Laurentian boulders, and some pieces of red and gray shale of the Quebec group, indicating the action of coast-ice when this terrace was cut. On the higher terrace there were also a few boulders; and both terraces are capped with pebbly sand and well rounded gravel, indicating the long-continued action of the waves at the levels which they represent.

LIST OF POST-PLIOCENE FOSSILS FOUND AT RIVIERE-DU-LOUP
AND CACOUNA.

*Those marked thus * have not previously been noticed as occurring in the
Canadian Post-pliocene.*

FORAMINIFERA.

Polymorphina lactea, Adams.

Nonionina Scapha, F. and M., and var. Labradorica, Dawson.

Polystomella striatopunctata, F. and M.

Biloculina ringens? Lam.

Entosolenia costata, Williamson.

* Truncatulina lobulata, W. and T.

* Rotalina? turgida, Williamson.

NOTE.—Since the publication of my former list of Foraminifera from the Post-pliocene of Canada (Can. Nat., vol. iv, 1859), I have found at Montreal, *Nonionina scapha* F. and M., *Dentalina pyrula* D'Orbigny, and *Orbulina universa* D'Orbigny. Messrs. Parker and Jones have also kindly revised my former list, and concur in all the determinations, with the exception of *Polystomella umbilicatula*, which they refer to *P. striatopunctata*, and *Bulimina auriculata* Bailey, which they refer to *B. pyrula* D'Orbigny.

PORIFERA.

* Halichondria—Silicious spicules.

ECHINODERMATA.

Echinus granularis, Say.

POLYZOA.

Lepralia Belli, Dawson.

L. pertusa, Thompson.

* L. producta, Packard.

* L. trispinosa, Johnston.

L. hyalina, Fabr.

* L. ventricosa, Hassel.

* Diastopora obelia, Johnston.

Tubulipora flabellaris? Johnston.

Hippothoa expansa, Dawson.

H. catenularia? Johnston.

- * *Eschara elegantula*, D'Orbigny.
- * *Celleporaria surcularis*, Packard.
- * *Myriozeugum subgracile*, D'Orbigny.
- * *Heteroporella radiata*?
- * *Alecto*.
- * *Membranipora Lacroixii*, Busk.

BRACHIOPODA.

- Rhynchonella psittacea*, Gm.
- * *Terebratella Labradorensis*, Sow.

LAMELLIBRANCHIATA.

- Pecten Islandicus*, Chemn.
- Leda truncata*, Brown, and vars. *siliqua* and *sulcifera*.
- * *L. tenuisulcata*, Couthouy, (*pernula*, Wood).
- L. minuta*, Mull, (*caudata*, Don.).
- * *L. limatula*, Say.
- Nucula tenuis*, Mont., (var. *expansa*).
- * *Modiolaria discors*, Linn.
- M. nigra*, Gray.
- Mytilus edulis*, Linn.
- * *Cardium Dawsoni*, Stimpson.
- * *Astarte compressa*, Mont. (*A. Banksii*, Leach).
- A. Laurentiana*, Lyell.
- Tellina Grœnlandica*, Beck.
- T. proxima*, Brown.
- T. (Macoma) inflata*, Stimpson.
- Mya arenaria*, Linn.
- M. truncata*, Linn., var. *Uddevallensis*.
- * *Panopæa Arctica*, Gould. (*P. Norvegica*?).
- Saxicava rugosa*, Linn., and var. *Arctica*.
- * *Lyonsia arenosa*, Moll.

NOTE.—Large suites of specimens from Rivière-du-Loup enable me to determine with certainty that *Leda tenuisulcata* Couthouy, *L. pernula* Muller, (& Wood, English Crag,) and *L. Jacksoni* Gould, are varieties of one species; that *Saxicava Arctica* is merely a variety of *S. rugosa*; and that *Leda siliqua* and *L. sulcifera* of Reeve are varieties of *L. truncata*, which is identical with *L. Portlandica* Gould.

GASTEROPODA.

- * *Cylichna nucleola*, Reeve.
- Acmea (Lepeta) cæca*, Mull.
- Cemoria Noachina*, Linn.
- * *Adeorbis costulata*?
- Margarita helicina*, Fabr., (*Arctica*).
- * *M. cinerea*, Couth.
- Littorina palliata*, Say.
- * *L. rudis*, Mont.
- Scalaria Grœnlandica*, Perry.

- Menestho albula, Moll.
 * Turritella erosa, Couth.
 Natica clausa, Sow.
 N. Grœnlandica, Mull.
 * N. catenoides? Wood.
 Bela harpularia, Gould, (Woodiana, Moll.).
 * B. violacea, Migh.
 * B. decussata, Couth.
 * B. turricula, Mont.
 B. rufa, Gould, (pyramidalis).
 Buccinum undatum, Linn., and var. Labradorensis, Reeve.
 * B. glaciale, Linn.
 * B. scalariforme, Moll.
 * B. cretaceum, Reeve.
 Fusus tornatus, Gould, and var. despectus, Linn.
 * Trophon clathratum, Linn.
 T. scalariforme, Gould.
 Trichotropis borealis, B. and S.

NOTE.—I regard *B. Labradorensis* as merely a variety of *B. undatum*, peculiar, like the oval or almond-shaped variety of *Mytilus edulis*, to the mouths of rivers. The species which I have named *B. cretaceum* is certainly distinct, but I am by no means sure that it is really *B. cretaceum* of Reeve. *B. glaciale* is common at Montreal and at St. Nicholas; but the specimens from Rivière-du-Loup enabled me for the first time to recognize it.

ANNULATA.

- * Spirorbis nautiloides, Lam.
 S. vitrea, Stimp.
 * S. sinistrorsa, Mont.
 * S. quadrangularis, Stimpson.

CRUSTACEA.

- Balanus Hameri, Asc., var. Uddevallensis.
 B. porcatus, Da Costa.
 B. crenatus, Brug.
 Cytheridea Mulleri, Mun.
 * Hyas coarctata, Leach.

Of the above species, *Pinopœa Norvegica*, *Fusus tornatus*, *Leda truncata*, *L. tenuisulcata*, *Astarte compressa*, *Mytilus edulis*, *Mya arenaria* and *Littorina palliata*, had been collected at Rivière-du-Loup, by the officers of the Survey, previous to my visit. *Mesodesma Jauresii* had also been collected from littoral gravels east of Cacouna, but was not met with by me.

ON THE GENUS WOODSIA.

By DANIEL C. EATON, M.A.

Professor of Botany in Yale College, New Haven.

This genus of ferns was established by the learned ROBERT BROWN in 1812, for the two species *Woodsia Ilvensis* and *W. hyperborea*; afterwards he added a third, *W. glabella*. These species all have a minute pateriform involucre, covered by the sporangia, and divided into numerous elongated ciliae. The genus has since been extended so as to include species having a more manifest involucre, at first globose or irregularly hemispherical, the margin commonly ciliated or irregularly lacinated. The genus thus extended embraces twelve or fifteen species, several of them occurring in the north-temperate and sub-arctic zones, and others following the Cordilleras and the Andes, from Mexico to Chile, or inhabiting the mountains of Northern India. All the species are small ferns, growing in tufts, mostly in crevices of exposed rocks, the stipes commonly very brittle, and remaining after the fronds have fallen away.

The species of this genus I propose to arrange as follows:

§ 1. Stipes articulated, the withered fronds falling away at the joint. Involucre beneath the sorus, pateriform, deeply divided into elongated ciliae which are inflexed over the sporangia.—

W. alpina and *Ilvensis*.

§ 2. Stipes not articulated.

A. Involucre as in § 1, but smaller, the ciliae scarcely visible among the sporangia.—*W. Oregana*, *scopulina*, and *Mexicana*.

B. Involucre cyathiform or globose, enveloping the sporangia, afterwards lacinatedly cleft into irregular lobes. (Physematium, Kaulf.)—*W. incisa*, *obtusa*, *mollis*, *Guatemalensis*, *Peruviana*, *Cumingiana*, and *elongata*.*

C. Indusium irregularly sub-globose, cystiform, divided into 4–6 ciliated lobes, which are imbricated over the sporangia.—*W. polystichoides*.

* *W. Caucasica* probably belongs here, but I have not had an opportunity of examining it. *Hypoderris Brownii* Wallich, also almost unknown to me, is referred to this genus by Mettenius:—it would constitute a third section, characterized by reticulated venation.

The species occurring in North America, excluding Mexico, are five, so far as known at present.

1. *WOODSIA ALPINA*. S. F. Gray, Natural Arrangement of British Plants, ii, p. 17. Moore, Nature-printed Ferns, (folio ed.), t. 47. *Acrostichum alpinum*, Bolton, Fil. Brit. p. 76, t. 42, (1790). *Woodsia hyperborea*, R. Brown, Trans. Linn. Soc., xi, p. 173, t. 11. Hook., British Ferns, t. 7 (excellent). *Acrostichum hyperboreum*, Liljeblad, Stockholm Trans. p. 201, t. 8, (1793).

Var. *GLABELLA*. *Woodsia glabella*. R. Brown in Rich. App. to Frankl. Journ., p. 39. Hook., Fl. Bor. Am. ii., p. 259, t. 237.

Hab.—Newfoundland to the Rocky Mountains and northward, scarcely occurring in the United States; the *var.* from Vermont and New York, to Behring's Straits (Charles Wright).

American specimens are less chaffy than common European forms, but not otherwise different. *W. glabella* has no characters to distinguish it from *W. alpina*, for the largest forms occur perfectly smooth, and the smallest ones are sometimes quite chaffy. *W. subcordata* Maximowicz, from the Amoor River, appears to be identical with *W. alpina*.

2. *WOODSIA ILVENSIS*. R. Brown, l. c. Hook., British Ferns, t. 8. Gray's Manual, ed. 2, p. 596. *Acrostichum Ilvense*, Linn. *Nephrodium rufidulum*, Michx., Fl. Bor. Am. ii, p. 269.

Hab.—New England to Wisconsin, southward along the Alleghanies, and northward to Greenland. Lake Winnipeg, Mr. Barnston; very fine specimens.

This fern is extremely variable in size and appearance, sometimes being scarcely an inch in height, while fine specimens from the Highlands of the Hudson River measure nine or ten inches, and grow in dense patches often two feet in breadth. It may always be distinguished from *W. alpina* by its greater chaffiness and longer pinnæ.

3. *WOODSIA OREGANA*, *sp. nov.*: caespitosa glabra; stipite inarticulato frondi sub-æquilongo basi paleaceo; frondibus elliptico-lanceolatis pinnatis, fructiferis duplo longioribus, pinnis alternis oppositisve triangulari-oblongis obtusis pinnatifidis, pinnulis ovatis dentatis obtusis; lobulis pinnularum primo reflexis sororumque celantibus mox explanatis, venulis sæpius furcatis; indusio fere nullo in ciliis perbreves moniliformi-articulatas fere ad centrum diviso.

Hab.—Dalles of the Columbia River, Oregon; Major Raines,

U. S. A., 1855, (referred to *W. hyperborea* in Hooker's British Ferns). Rocky Mountains, near 40° north latitude; Hall and Harbour, No. 690a.

Fronds quite smooth, 2–8 inches high, 8–12 lines wide, the fertile ones much taller than the sterile, pinnate; pinnae 9–13 pairs, the lower ones smaller, triangular and rather remote, the upper ones more crowded and larger, pinnately lobed into 3–6 divisions on each side, the divisions more or less toothed; the teeth irregular, rather acute, at first reflexed (at least in the dried specimens), but as the sporangia ripen, the frond becomes more coriaceous and at length explanate. The involucre is exceedingly minute, and consists of a few articulated ciliae composed of a single series of nearly globular cells. In general appearance this little fern resembles small forms of *W. obtusa*, from which however the glabrous fronds and the rudimentary involucre at once distinguish it.

4. *WOODSIA SCOPULINA*, *sp. nov.*: caespitosa glanduloso-pubescent; stipite inarticulato frondibus brevioribus basi paleaceo, frondibus erectis elongato-lanceolatis acuminatis pinnatis fere bipinnatis subtus secus venas paleolis unicæ cellularum seriei minute pubescentibus glandulisque fuscis conspersis; pinnis plerumque oppositis oblongo-lanceolatis sub-acutis fere ad costam pinnatifidis, pinnulis crebris oblongis obtusis crenatis vel crenato-lobatis; lobulis soriiferis; involucro tenerrimo vix conspicuo profunde laciniato; laciniis in ciliis breves articulatas angustatis.

Hab.—Rocky Mountains, near 40° north latitude; Parry No. 394, Hall and Harbour No. 690b. Columbia River; Brackenridge, (*W. Ilvensis*.) U. S. Expl. Exped. Fraser's River, near 49° north latitude; Mrs. John Miles.

A graceful species, quite distinct from all others. Stipes, as in the last straw-color above, chestnut-brown at the base, where it is chaffy with ovate acuminate brown scales. Fronds, several from the caudex, 4–10 inches high, 12–18 lines wide; finely pubescent everywhere along the rachis, costa, and veins, except on the upper surface, with slender flattened hairs, and sprinkled beneath with very minute, often compound glands; apparently bipinnate, but the costa of the primary pinnae is narrowly winged. Pinnae 12–20 pairs, oblong lanceolate or somewhat triangular in outline. Pinnules 6–10 pairs, ovate-oblong, crenately lobed, the teeth rather obtuse, not reflexed when young. The involucre is more evident than in the last, and consists of a central portion deeply and irregularly cleft into laciniae, which are narrowed into rather short articulated

ciliæ, the cells of the ciliæ irregularly cylindrical. *W. Mexicana* Fée, as figured, has an involucre somewhat resembling this one, and I suppose it may belong to the same group.

5. *WOODSIA OBTUSA*. Torrey, Cat. Pl. in Geol. Report of New York, 1840. Hooker, Species Filicum, i, p. 62. *Polypodium obtusum*, Swartz, Syn. Fil., p. 39.

Hab.—New England to North Carolina, and westward to Wisconsin and Missouri. (On the Columbia River, Hook. Fl. Bor. Am., but the specimens are more likely to be *W. scopulina*.) Specimens from Texas, Ch. Wright, Nos. 830 and 2120, I refer to this species somewhat doubtfully, as the involucre is cleft into very narrow laciniately fringed lobes. Better specimens are needed to show what the plant really is.

New Haven, Connecticut, U. S. A., March 15, 1865.

ON THE OCCURRENCE OF ORGANIC REMAINS IN THE LAURENTIAN ROCKS OF CANADA.*

By Sir W. E. Logan, LL.D., F.R.S., F.G.S.; Director of the Geological Survey of Canada.

The oldest known rocks of North America are those which compose the Laurentide Mountains in Canada and the Adirondacks in the State of New York. By the investigations of the Geological Survey of Canada, they have been shown to be a great series of strata, which, though profoundly altered, consist chiefly of quartzose, aluminous, and calcareous rocks, like the sedimentary deposits of less ancient times. This great mass of crystalline rocks is divided into two groups, and it appears that the Upper rests unconformably upon the Lower Laurentian series.

* This, and the three following papers, by Messrs. Dawson, Carpenter and Sterry Hunt are reprinted from the Quarterly Journal of the Geological Society of London, for February, 1865. Some additional notes by the authors and editors are distinguished by being included in brackets. See also a supplementary note by Dr. Dawson, on the discovery of Eozoön in Ireland on page 126.

In place of the lithographed plates published in the Quarterly Journal to illustrate the papers of Messrs. Dawson and Carpenter, selections from those, filling a single plate, are here given; besides which three woodcuts are added.—Eds.

The united thickness of these two groups in Canada cannot be less than 30,000 feet, and probably much exceeds it. The Laurentian of the west of Scotland, according to Sir Roderick Murchison, also attains a great thickness. In that region the Upper Laurentian or Labrador series, has not yet been separately recognized; but from Mr. McCulloch's description, as well as from the specimens collected by him, and now in the Museum of the Geological Society of London, it can scarcely be doubted that the Labrador series occurs in Skye.* The labradorite and hypersthene rocks from that island are identical with those of the Labrador series in Canada and New York, and unlike those of any formation at any other known horizon. This resemblance did not escape the notice of Emmons, who, in his description of the Adirondack Mountains, referred these rocks to the hypersthene rock of McCulloch, although these observers, on the opposite sides of the Atlantic, looked upon them as unstratified. In the Canadian Naturalist for 1862, Mr. Thomas Macfarlane, for some time resident in Norway, and now in Canada, drew attention to the striking resemblance between the Norwegian primitive gneiss formation, as described by Naumann and Keilhau, and observed by himself, and the Laurentian, including the Labrador group; and the equally remarkable similarity of the lower part of the primitive slate formation to the Huronian series, which is a third Canadian group. These primitive series attain a great thickness in the north of Europe, and constitute the main features of Scandinavian geology.

In Bavaria and Bohemia there is an ancient gneissic series. After the labours in Scotland, by which he was the first to establish a Laurentian equivalent in the British Isles, Sir Roderick Murchison, turning his attention to this central European mass, placed it on the same horizon. These rocks, underlying Barrande's Primordial zone, with a great development of intervening clay-slate, extend southward in breadth to the banks of the Danube, with a prevailing dip towards the Silurian strata. They had previously

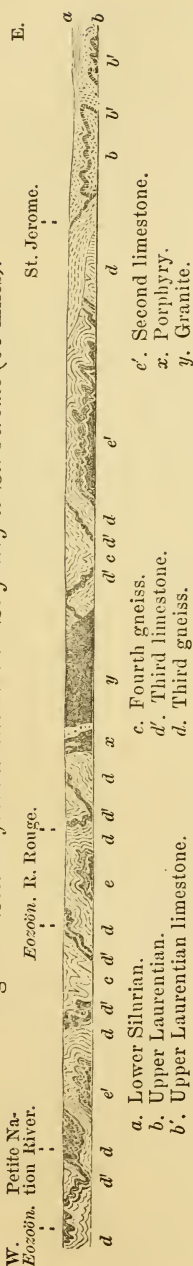
[* This was first shown by Mr. T. Sterry Hunt, after his examinations of McCulloch's collections, in a paper published in the Dublin Quar. Journal of Science for 1863, p. 230. See also Silliman's Journal [2] xxxvi. 226, and Canadian Naturalist, vi. 208. Prof. Haughton of Dublin has since visited the islands of Skye and Iona, and confirmed the observations of Mr. Hunt. See Proc., of the Royal Geological Society of Dublin for Dec. 14, 1864, in the Geol. Magazine for February, 1865, page 73.—Eds.]

been studied by Gümbel and Crejci, who divided them into an older reddish gneiss and a newer grey gneiss. But, on the Danube, the mass which is furthest removed from the Silurian rocks being a grey gneiss, Gümbel and Crejci account for its presence by an inverted fold in the strata ; while Sir Roderick places this at the base, and regards the whole as a single series, in the normal fundamental position of the Laurentian of Scotland and of Canada. Considering the colossal thickness given to the series (90,000 feet), it remains to be seen whether it may not include both the Lower and Upper Laurentian, and possibly, in addition, the Huronian.

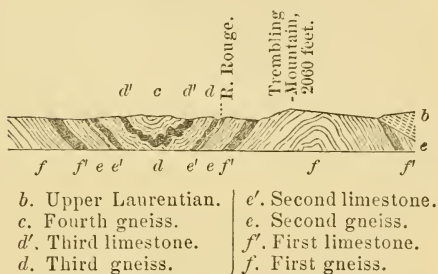
This third Canadian group (the Huronian) has been shown by my colleague, Mr. Murray, to be about 18,000 feet thick, and to consist chiefly of quartzites, slate-conglomerates, diorites, and limestones. The horizontal strata which form the base of the Lower Silurian in western Canada, rest upon the upturned edges of the Huronian series ; which, in its turn, unconformably overlies the Lower Laurentian. The Huronian is believed to be more recent than the Upper Laurentian series, although the two formations have never yet been seen in contact.

The united thickness of these three great series may possibly far surpass that of all the succeeding rocks from the base of the Palæozoic series to the present time. We are thus carried back to a period so far remote, that the appearance of the so-called Primordial fauna may by some be considered a comparatively modern event. We, however, find that, even during the Laurentian period, the same chemical and mechanical processes which have ever since been at work disintegrating and reconstructing the earth's crust were in operation as now. In the conglomerates of the Huronian series there are enclosed boulders derived from the Laurentian, which seem to show that the parent rock was altered to its present crystalline condition before the deposit of the newer formation ; while interstratified with the Laurentian limestones there are beds of conglomerate, the pebbles of which are themselves rolled fragments of a still older laminated sand-rock, and the formation of these beds leads us still further into the past.

In both the Upper and Lower Laurentian series there are several zones of limestone, each of sufficient volume to constitute an independent formation. Of these calcareous masses it has been ascertained that three, at least, belong to the Lower Laurentian. But, as we do not as yet know with certainty either the base or the summit of this series, these three may be conformably fol-

Fig. 1.—Section from *Petite Nation Seigniorie to St. Jerome* (66 miles).

lowed by many more. Although the Lower and Upper Laurentian rocks spread over more than 200,000 square miles in Canada, only about 1500 square miles have yet been fully and connectedly examined in any one district, and it is still impossible to say whether the numerous exposures of Laurentian limestone met with in other parts of the province are equivalent to any of the three zones, or whether they overlie or underlie them all.

Fig. 2.—Section across *Trembling Mountain* (21 miles).

In the examination of these ancient rocks, the question often naturally occurred to me whether, during these remote periods, organic life had yet appeared on the earth. The apparent absence of fossils from the highly crystalline limestones did not seem to offer a proof in negation, any more than their undiscovered presence in newer crystalline limestones, where we have little doubt they have been obliterated by metamorphic action; while the carbon which, in the form of graphite, constitutes beds, or is disseminated through the calcareous or siliceous strata of the Laurentian series, seemed to be an evidence of the existence of vegetation, since no one disputes the organic origin of this mineral in more recent rocks. My colleague, Dr. T. Sterry

Hunt, has argued for the existence of organic matters at the earth's surface during the Laurentian period from the presence of great beds of iron-ore, and from the occurrence of metallic sulphurets*; and finally, the evidence was strengthened by the discovery of supposed organic forms. These were first brought to me, in October, 1858, by Mr. J. McMullen, then attached as an explorer, to the Geological Survey of the province, from one of the limestones of the Laurentian series occurring at the Grand Calumet, on the River Ottawa.

Any organic remains which may have been entombed in these limestones would, if they retained their calcareous character, be almost certainly obliterated by crystallization; and it would only be by the replacement of the original carbonate of lime by a different mineral substance, or by an infiltration of such a substance into all the pores and spaces in and about the fossil, that its form would be preserved. The specimens from the Grand Calumet present parallel or apparently concentric layers resembling those of *Stromatopora*, except that they anastomose at various points. What were first considered the layers are composed of crystallized pyroxene, when the then supposed interstices consist of carbonate of lime. These specimens, one of which is figured, in 'Geology of Canada,' p. 49,† called to memory others which had some years previously been obtained from Dr. James Wilson, of Perth, and were then regarded merely as minerals. They came, I believe, from masses in Burgess, but whether in place is not quite certain; and they exhibit similar forms to those of the Grand Calumet, composed of layers of a dark green magnesian silicate (loganite); while what were taken for the interstices are filled with crystalline dolomite. If the specimens from both these places were to be regarded as the result of unaided mineral arrangement, it appeared to me strange that identical forms should be derived from minerals of such different composition. I was therefore disposed to look upon them as fossils, and as such they were exhibited by me at the meeting of the American Association for the Advancement of Science, at Springfield, in August 1859. See Canadian Naturalist, 1859, iv, 300. In 1862 they were shown to to some of my geological friends in Great Britain; but no microscopic structure having been observed belonging to them, few seemed disposed to believe in their organic character, with the exception of my friend Professor Ramsay.

* Quarterly Journal of the Geological Society, xv, 493.

[† Reproduced below, page 100, figures 1 and 2.]

One of the specimens had been sliced and submitted to microscopic observation, but unfortunately it was one of those composed of loganite and dolomite. In these, the minute structure is rarely seen. The true character of the specimens thus remained in suspense until last winter, when I accidentally observed indications of similar forms in blocks of Laurentian limestone which had been brought to our museum by Mr. James Lowe, one of our explorers, to be sawn up for marble. In this case the forms were composed of serpentine and calc-spar; and slices of them having been prepared for the microscope, the minute structure was observed in the first one submitted to inspection. At the request of Mr. Billings, the palæontologist of our Survey, the specimens were confided for examination and description to Dr. J. W. Dawson, of Montreal, our most practised observer with the microscope; and the conclusions at which he has arrived are appended to this communication. He finds that the serpentine, which was supposed to replace the organic form, really fills the interspaces of the calcareous fossil. This exhibits in some parts a well-preserved organic structure, which Dr. Dawson describes as that of a Foraminifer, growing in large sessile patches after the manner of *Polytrema* and *Carpenteria*, but of much larger dimensions, and presenting minute points which reveal a structure resembling that of other Foraminiferal forms, as, for example, *Calcarina* and *Nummulina*.

Dr. Dawson's description is accompanied by some remarks by Dr. Sterry Hunt on the mineralogical relations of the fossil. He observes that while the calcareous septa which form the skeleton of the Foraminifer in general remain unchanged, the sarcode has been replaced by certain silicates which have not only filled up the chambers, cells, and septal orifices, but have been injected into the minute tubuli, which are thus perfectly preserved, as may be seen by removing the calcareous matter by an acid. The replacing silicates are white pyroxene, serpentine, loganite, and pyrrallolite or rensseleerite. The pyroxene and serpentine are often found in contact, filling contiguous chambers in the fossil, and were evidently formed in consecutive stages of a continuous process. In the Burgess specimens, while the sarcode is replaced by loganite, the calcareous skeleton, as has already been stated, has been replaced by dolomite, and the finer parts of the structure have been almost wholly obliterated. But in the other specimens, where the skeleton still preserves its calcareous character, the resemblance between the mode of preservation of the ancient Laurentian *For-*

aminifera and that of the allied forms in Tertiary and recent deposits (which, as Ehrenberg, Bailey, and Pourtales have shown, are injected with glauconite), is obvious.

The Grenville specimens belong to the highest of the three already mentioned zones of Laurentian limestone, and it has not yet been ascertained whether the fossil extends to the two conformable lower ones, or to the calcareous zones of the overlying unconformable Upper Laurentian series. It has not yet either been determined what relation the strata from which the Burgess and Grand Calumet specimens have been obtained bear to the Grenville limestone or to one another. The zone of Grenville limestone is in some places about 1500 feet thick, and it appears to be divided for considerable distances into two or three parts by very thick bands of gneiss. One of these occupies a position towards the lower part of the limestone, and may have a volume of between 100 and 200 feet. It is at the base of the limestone that the fossil occurs. This part of the zone is largely composed of great and small irregular masses of white crystalline pyroxene, some of them twenty yards in length by four or five wide. They appear to be confusedly placed one above another, with many ragged interstices, and smoothly-worn, rounded large and small pits and sub-cylindrical cavities, some of them pretty deep. The pyroxene, though it appears compact, presents a multitude of small spaces consisting of carbonate of lime, and many of these show minute structures similar to that of the fossil. These masses of pyroxene may characterize a thickness of about 200 feet, and the interspaces among them are filled with a mixture of serpentine and carbonate of lime. In general a sheet of pure dark green serpentine invests each mass of pyroxene; the thickness of the serpentine, varying from the sixteenth of an inch to several inches, rarely exceeding half a foot. This is followed in different spots by parallel, waving, irregularly alternating plates of carbonate of lime and serpentine, which become gradually finer as they recede from the pyroxene, and occasionally occupy a total thickness of five or six inches. These portions constitute the unbroken fossil, which may sometimes spread over an area of about a square foot, or perhaps more. Other parts, immediately on the outside of the sheet of serpentine, are occupied with about the same thickness of what appear to be the ruins of the fossil, broken up into a more or less granular mixture of calc-spar and serpentine, the former still showing minute structure; and on the outside of the whole a similar mixture appears to have been swept

by currents and eddies into rudely parallel and curving layers; the mixture becoming gradually more calcareous as it recedes from the pyroxene. Sometimes beds of limestone of several feet in thickness, with the green serpentine more or less aggregated into layers, and studded with isolated lumps of pyroxene, are irregularly interstratified in the mass of rock; and less frequently there are met with lenticular patches of sandstone or granular quartzite, of a foot in thickness and several yards in diameter, holding in abundance small disseminated leaves of graphite.

The general character of the rock connected with the fossil produces the impression that it is a great Foraminiferal reef, in which the pyroxenic masses represent a more ancient portion, which having died, and having become much broken up and worn into cavities and deep recesses, afforded a seat for a new growth of *Foraminifera*, represented by the calcareo-serpentinous part. This in its turn became broken up, leaving in some places uninjured portions of the general form. The main difference between this Foraminiferal reef and more recent coral-reefs seems to be that, while with the latter are usually associated many shells and other organic remains, in the more ancient one the only remains yet found are those of the animal which built the reef.

ON CERTAIN ORGANIC REMAINS IN THE LAURENTIAN LIMESTONES OF CANADA.*

By J. W. DAWSON, LL.D., F.R.S.,

Principal of McGill University, Montreal, Canada.

At the request of Sir William E. Logan, I have submitted to microscopic examination slices of certain peculiar laminated forms consisting of alternate layers of carbonate of lime and serpentine, or of carbonate of lime and white pyroxene, found in the Laurentian limestones of Canada, and regarded by Sir William as possibly fossils.† I have also examined slices of a number of limestones and serpentines from the Laurentian series, not showing the external forms of these supposed fossils.

The slices were prepared by the lapidary of the Survey, and were carefully examined under ordinary and polarized light, with

[* See a preliminary notice in Silliman's Journal [2], xxxvii, 272.]

† Canadian Naturalist, 1859, p. 300.

objectives made by Ross, and by Smith and Beck; and also with good French objectives.



1. Weathered specimen of *Eozoön Canadense* from the Calumet, of the natural size. The replacing silicate is white pyroxene.



2. Vertical transverse section of the specimen figure 1.

The specimens first mentioned are masses, often several inches in diameter, presenting to the naked eye alternate laminae of serpentine, or of pyroxene, and carbonate of lime. Their general aspect, as remarked by Sir W. E. Logan (*Geology of Canada*, 1863, p. 49), reminds the observer of that of the Silurian corals of the genus *Stromatopora*, except that the laminae diverge from and approach each other, and frequently anastomose or are connected by transverse septa.

Under the microscope the resemblance to *Stromatopora* is seen to be in general form merely, and no trace appears of the radiating cells characteristic of that genus. The laminæ of serpentine and pyroxene present no organic structure, and the latter mineral is highly crystalline. The laminæ of carbonate of lime, on the contrary, retain distinct traces of structures which cannot be of a crystalline or concretionary character. They constitute parallel or concentric partitions of variable thickness, enclosing flattened spaces or chambers, frequently crossed by transverse plates or septa, in some places so numerous as to give a vesicular appearance, in others



3. Nature-printed section of a specimen of *Eozoön Canadense* from Petite Nation Seigniory.*

[* The replacing mineral in this specimen being serpentine, the calcareous septa were dissolved from the polished surface by the action of an acid, and the fine material replacing the tubuli having been removed by the aid of a brush, a wax mould of the etched surface furnished the electrotpe cast from which the above figure is printed. The lights thus represent the calcareous skeleton, and the shaded portion a thick mass of serpentine, which is distinguishable from a contiguous thin stratum of the same mineral, that seems to form the base of the Eozoön. The gradual passage from the wide chambers and thick septa to the nar-

occurring only at rare intervals (figure 3). The laminae themselves are excavated on their sides into rounded pits, and are in some places traversed by canals, or contain secondary rounded cells, apparently isolated. In addition to these general appearances, the substance of the laminae, where most perfectly preserved, is seen to present a fine granular structure, and to be penetrated by numerous minute tubuli, which are arranged in bundles of great beauty and complexity, diverging in sheaf-like forms, and in their finer extensions anastomosing so as to form a net-work (plate, figures 2 and 4). In transverse sections, and under high powers, the tubuli are seen to be circular in outline, and sharply defined (plate, figure 5). In longitudinal sections, they sometimes present a beaded or jointed appearance. Even where the tubular structure is least perfectly preserved, traces of it can still be seen in most of the slices, though there are places in which the laminae are perfectly compact, and perhaps were so originally.

Faithful delineations of these structures have been prepared by Mr. Horace Smith, the artist of the Survey, which will render them more intelligible than any verbal description.

With respect to the nature and probable origin of the appearances above described, I would make the following remarks :

1. The serpentine and pyroxene which fill the cavities of the calcareous matter have no appearance of concretionary structure. On the contrary, their aspect is that of matter introduced by infiltration, or as sediment, and filling spaces previously existing. In other words, the calcareous matter has not been moulded on the forms of the serpentine and augite, but these have filled spaces or chambers in a hard calcareous mass. This conclusion is further confirmed by the fact, to be referred to in the sequel, that the serpentine includes multitudes of minute foreign bodies, while the calcareous matter is uniform and homogeneous. It is also to be observed that small veins of carbonate of lime occasionally traverse the specimens, and in their entire absence of structures other than crystalline, present a striking contrast to the supposed fossils.

2. Though the calcareous laminae have in places a crystalline

rower and thinner ones, and finally to the irregularly aggregated mode of growth, designated by Dr. Carpenter as *acervuline*, is well seen. The white patches in the upper portion of the figure do not arise from any imperfection in the electrotpe, but represent the irregular growth of this part of the calcareous skeleton.—T. S. H.]

cleavage, their forms and structures have no relation to this. Their cells and canals are rounded, and have smooth walls, which are occasionally lined with films apparently of carbonaceous matter. Above all, the minute tubuli are different from anything likely to occur in merely crystalline calc-spar. While in such rocks little importance might be attached to external forms simulating the appearances of corals, sponges, or other organisms, these delicate internal structures have a much higher claim to attention. Nor is there any improbability in the preservation of such minute parts in rocks so highly crystalline, since it is a circumstance of frequent occurrence in the microscopic examination of fossils that the finest structures are visible in specimens in which the general form and the arrangement of parts have been entirely obliterated. It is also to be observed that the structure of the calcareous laminæ is the same, whether the intervening spaces are filled with serpentine or with pyroxene.

3. The structures above described are not merely definite and uniform, but they are of a kind proper to animal organisms, and more especially to one particular type of animal life, as likely as any other to occur under such circumstances; I refer to that of the Rhizopods of the order *Foraminifera*. The most important point of difference is in the great size and compact habit of growth of the specimens in question; but there seems no good reason to maintain that *Foraminifera* must necessarily be of small size, more especially since forms of considerable magnitude referred to this type are known in the Lower Silurian. Prof. Hall has described specimens of *Receptaculites* twelve inches in diameter; and the fossils from the Potsdam formation of Labrador, referred by Mr. Billings to the genus *Archæocyathus*, are examples of *Protozoa* with calcareous skeletons scarcely inferior in their massive style of growth to the forms now under consideration.*

[* The following note is inserted in place of another, which, by an error of the printer, is in the Quarterly Journal of the Geological Society incorporated with the text:

Mr. Billings has ascertained, since this paper was written, that one of the species included in the genus *Archæocyathus*, has silicious spicula which would place it with the sponges. But two other species of the genus have, in accordance with his original description, a chambered calcareous skeleton, which is, in my opinion, similar to that of *Foraminifera*. (Memoirs of the Geological Survey of Canada, Nov. 1861, and reprint of the same in 1864.)—J. W. D.]

These reasons are, I think, sufficient to justify me in regarding these remarkable structures as truly organic, and in searching for their nearest allies among the *Foraminifera*.

Supposing then that the spaces between the calcareous laminae, as well as the canals and tubuli traversing their substance, were once filled with the sarcode body of a Rhizopod, comparisons with modern forms at once suggest themselves.

From the polished specimens in the Museum of the Canadian Geological Survey, it appears certain that these bodies were sessile, with a broad base, and grew by the addition of successive layers of chambers separated by calcareous laminae, but communicating with each other by canals or septal orifices sparsely and irregularly distributed. Small specimens have thus much the aspect of the modern genera *Carpenteria* and *Polytrema*. Like the first of these genera, there would also seem to have been a tendency to leave in the midst of the structure a large central canal, or deep funnel-shaped or cylindrical opening, for communication with the sea-water. Where the laminae coalesce, and the structure becomes more vesicular, it assumes the 'acervuline' character seen in such modern forms as *Nubecularia*.

Still the magnitude of these fossils is enormous when compared with the species of the genera above named; and from the specimens in the larger slabs from Grenville, in the Museum of the Canadian Survey, it would seem that these organisms grew in groups, which ultimately coalesced, and formed large masses penetrated by deep irregular canals; and that they continued to grow at the surface, while the lower parts became dead and were filled up with infiltrated matter or sediment. In short, we have to imagine an organism having the habit of growth of *Carpenteria*, but attaining to an enormous size, and by the aggregation of individuals assuming the aspect of a coral reef.

The complicated systems of tubuli in the Laurentian fossil indicate, however, a more complex structure than that of any of the forms mentioned above. I have carefully compared these with the similar structures in the 'supplementary skeleton' (or the shell-substance that carries the vascular system) of *Calcarina* and other forms,* and can detect no difference except in the somewhat

* I desire to express my obligations to the invaluable memoirs of Dr. Carpenter on the *Foraminifera*, in the Transactions of the Royal Society, and in the publications of the Ray Society; without which

coarser texture of the tubuli in the Laurentian specimens. It accords well with the great dimensions of these, that they should thus thicken their walls with an extensive deposit of tubulated calcareous matter; and from the frequency of the bundles of tubuli, as well as from the thickness of the partitions, I have no doubt that all the successive walls, as they were formed, were thickened in this manner, just as in so many of the higher genera of more modern *Foraminifera*.

It is proper to add that no spicules, or other structures indicating affinity to the Sponges, have been detected in any of the specimens.

As it is convenient to have a name to designate these forms, I would propose that of *Eozoön*, which will be specially appropriate to what seems to be the characteristic fossil of a group of rocks which must now be named *Eozoic* rather than *Azoic*. For the species above described, the specific name of *Canadense* has been proposed. It may be distinguished by the following characters:—

EOZOÖN CANADENSE; *gen. et spec. nov.*

General form.—Massive, in large sessile patches or irregular cylinders, growing at the surface by the addition of successive laminae.

Internal structure.—Chambers large, flattened, irregular, with numerous rounded extensions, and separated by walls of variable thickness, which are penetrated by septal orifices irregularly disposed. Thicker parts of the walls with bundles of fine branching tubuli.

These characters refer specially to the specimens from Grenville and the Calumet. There are others from Perth, C. W., which show more regular laminae, and in which the tubuli have not yet been observed; and a specimen from Burgess, C. W., contains some fragments of laminae which exhibit, on one side, a series of fine parallel tubuli like those of *Nummulina*. These specimens may indicate distinct species; but on the other hand, their peculiarities may depend on different states of preservation.

With respect to this last point, it may be remarked that some of

it would have been impossible satisfactorily to investigate the structure and affinities of *Eozoön*. I have also to acknowledge the kindness of Dr. Carpenter in furnishing me with specimens of some of the forms described in his works.

the specimens from Grenville and the Calumet show the structures of the laminae with nearly equal distinctness whether the chambers have been filled with serpentine or pyroxene, and that even the minute tubuli are penetrated and filled with these minerals. On the other hand, there are large specimens in the collection of the Canadian Survey, in which the lower and older parts of the masses of *Eozoön* are mineralized with pyroxene, and have to a great extent lost the perfection of structure which characterizes the more superficial parts of the same masses, in which the chambers have been filled with a light green serpentine. Dr. Sterry Hunt has directed his attention to the conditions of deposit of these minerals, and will, I have no doubt, be able satisfactorily to explain the manner in which they may have been introduced into the chambers of the fossils without destroying the texture of the latter.

It is due to Dr. Sterry Hunt to state that, as far back as 1858, in a paper published in the Quarterly Journal of the Geological Society,* he insisted on certain chemical characters of the Laurentian beds as affording "evidence of the existence of organic life at the time of the deposition of these old crystalline rocks"; and that he has zealously aided in the present researches.

I may also state that Mr. Billings, the palæontologist of the Survey, has joined in the request that I should undertake the examination and description of the specimens, as being more specially a subject of microscopical investigation.

Before concluding this part of the subject, it is proper to observe that the structures above described can be made out only by the careful study of numerous slices, and in some instances only with polarized light. Even in the more perfect specimens of *Eozoön*, as those accustomed to such researches will readily understand, the accidents of good preservation and the cutting of the slices in the proper place and direction must conspire in order to a clear definition of the more minute structures.

It is also to be observed that the specimens present numerous remarkable microscopic appearances, depending on crystallization and concretionary action, which must not be confounded with organic structure. It would be out of place to give any detailed description of them here; but it is necessary to caution observers unaccustomed to the examination of mineral substances under the microscope, as to their occurrence. I may also mention that the

* Vol. xv, p. 493.

serpentine presents many curious varieties of structure, especially when associated with apatite, pyroxene, and other minerals, and that it affords magnificent objects under polarized light, when reduced to sufficiently thin slices.

In connexion with these remarkable remains, it appeared desirable to ascertain, if possible, what share these or other organic structures may have had in the accumulation of the limestones of the Laurentian series. Specimens were therefore selected by Sir W. E. Logan, and slices were prepared under his direction. On microscopic examination, a number of these were found to exhibit merely a granular aggregation of crystals, occasionally with particles of graphite and other foreign minerals; or a laminated mixture of calcareous and other matters, in the manner of some more modern sedimentary limestones. Others, however, were evidently made up almost entirely of fragments of *Eozoön*, or of mixtures of these with other calcareous and carbonaceous fragments which afford more or less evidence of organic origin. The contents of these organic limestones may be considered under the following heads:—

1. Remains of *Eozoön*.
2. Other calcareous bodies, probably organic.
3. Objects imbedded in the serpentine.
4. Carbonaceous matters.
5. Perforations, or worm-burrows.

1. The more perfect specimens of *Eozoön* do not constitute the mass of any of the larger specimens in the collection of the Survey; but considerable portions of some of them are made up of material of similar minute structure, destitute of lamination, and irregularly arranged. Some of this material gives the impression that there may have been organisms similar to *Eozoön*, but growing in an irregular or acervuline manner without lamination. Of this, however, I cannot be certain; and on the other hand there is distinct evidence of the aggregation of fragments of *Eozoön* in some of these specimens. In some they constitute the greater part of the mass. In others they are imbedded in calcareous matter of a different character, or in serpentine or granular pyroxene. In most of the specimens the cells of the fossils are more or less filled with these minerals; and in some instances it would appear that the calcareous matter of fragments of *Eozoön* has been in part replaced by serpentine.

2. Intermixed with the fragments of *Eozoön* above referred to, are other calcareous matters apparently fragmentary. They are of various angular and rounded forms, and present several kinds of structure. The most frequent of these is a strong lamination, varying in direction according to the position of the fragments, but corresponding, as far as can be ascertained, with the diagonal of the rhombohedral cleavage. This structure, though crystalline, is highly characteristic of crinoidal remains when preserved in altered limestones. The more dense parts of *Eozoön*, destitute of tubuli, also sometimes show this structure, though less distinctly.

Other fragments are compact and structureless, or show only a fine granular appearance; and these sometimes include grains, patches, or fibres of graphite. In Silurian limestones, fragments of corals and shells which have been partially infiltrated with bituminous matter show a structure like this. On comparison with altered organic limestones of the Silurian system, these appearances would indicate that, in addition to the debris of *Eozoön*, other calcareous structures, more like those of crinoids, corals, and shells, have contributed to the formation of the Laurentian limestones.

3. In the serpentine* filling the chambers of a large specimen of *Eozoön* from Burgess, there are numerous small pieces of foreign matter; and the silicate itself is laminated, indicating its sedimentary nature. Some of the included fragments appear to be carbonaceous, others calcareous; but no distinct organic structure can be detected in them. There are however in the serpentine many minute rounded siliceous grains of a bright green color, resembling green-sand concretions; and the manner in which these are occasionally arranged in lines and groups suggests the supposition that they may possibly be casts of the interior of minute Foraminiferal shells. They may however be concretionary in their origin.

4. In some of the Laurentian limestones submitted to me by Sir W. E. Logan, and in others which I collected some years ago at Madoc, Canada West, there are fibres and granules of carbonaceous matter, which do not conform to the crystalline structure, and present forms quite similar to those which in more modern limestones result from the decomposition of algæ. Though retaining mere traces of organic structure, no doubt would be entertained

[* This is the dark green mineral named loganite by Dr. Hunt.]

as to their vegetable origin if they were found in fossiliferous limestones.

5. A specimen of impure limestone from Madoc, in the collection of the Canadian Geological Survey, which seems from its structure to have been a finely laminated sediment, shows perforations of various sizes, somewhat scalloped at the sides, and filled with grains of rounded siliceous sand. In my own collection there are specimens of micaceous slate from the same region, with indications on their weathered surfaces of similar rounded perforations, having the aspect of *Scolithus*, or of worm-burrows.

I would observe, in conclusion, that the observations detailed in this paper must be regarded as merely an introduction to a most interesting and promising field of research. The specimens to which I had access were for the most part collected by the explorers of the Survey merely as rocks, and without any view to the possible existence of fossils in them. It may be hoped, therefore, that other and more perfect specimens may reward a careful search in the localities from which those now described have been obtained.

Further, though the abundance and wide distribution of *Eozoön*, and the important part it seems to have acted in the accumulation of limestone, indicate that it was one of the most prevalent forms of animal existence in the seas of the Laurentian period, the non-existence of other organic beings is not implied. On the contrary, independently of the indications afforded by the limestones themselves, it is evident that in order to the existence and growth of these large Rhizopods, the waters must have swarmed with more minute animal or vegetable organisms on which they could subsist. On the other hand, though this is a less certain inference, the dense calcareous skeleton of *Eozoön* may indicate that it also was liable to the attacks of animal enemies. It is also possible that the growth of *Eozoön*, or the deposition of the serpentine and pyroxene in which its remains have been preserved, or both, may have been connected with certain oceanic depths and conditions, and that we have as yet revealed to us the life of only certain stations in the Laurentian seas. Whatever conjectures we may form on these more problematic points, the observations above detailed appear to establish the following conclusions :—First, that in the Laurentian period, as in subsequent geological epochs, the Rhizopods were important agents in the accumulation of beds of limestone; and secondly, that in this early period these low forms of animal life attained to a development, in point of magnitude

and complexity, unexampled, in so far as yet known, in the succeeding ages of the earth's history. This early culmination of the Rhizopods is in accordance with one of the great laws of the succession of living beings ascertained from the study of the introduction and progress of other groups; and, should it prove that these great Protozoans were really the dominant type of animals in the Laurentian period, this fact might be regarded as an indication that in these ancient rocks we may actually have the records of the first appearance of animal life on our planet.

Since the above was written, thick slices of *Eozoön* from Grenville have been prepared, and submitted to the action of hydrochloric acid until the carbonate of lime was removed. The serpentine then remains as a cast of the interior of the chambers, showing the form of their original sarcode-contents. The minute tubuli are found also to have been filled with a substance insoluble in the acid, so that casts of these also remain in great perfection, and allow their general distribution to be much better seen than in the transparent slices previously prepared. These interesting preparations establish the following additional structural points:

1. That the whole mass of sarcode throughout the organism was continuous; the apparently detached secondary chambers being, as I had previously suspected, connected with the larger chambers by canals filled with sarcode.

2. That some of the irregular portions without lamination are not fragmentary, but due to the acervuline growth of the animal; and that this irregularity has been produced in part by the formation of projecting patches of supplementary skeleton, penetrated by beautiful systems of tubuli. These groups of tubuli are in some places very regular, and have in their axes cylinders of compact calcareous matter. Some parts of the specimens present arrangements of this kind as symmetrical as in any modern Foraminiferal shell.

3. That all except the very thinnest portions of the walls of the chambers present traces, more or less distinct, of a tubular structure.

4. These facts place in more strong contrast the structure of the regularly laminated specimens from Burgess, which do not show tubuli, and that of the Grenville specimens, less regularly laminated and tubulous throughout. I hesitate however to regard these two as distinct species, in consequence of the intermediate characters

presented by specimens from the Calumet, which are regularly laminated like those of Burgess, and tubulous like those of Grenville. It is possible that in the Burgess specimens tubuli originally present have been obliterated; and in organisms of this grade, more or less altered by the processes of fossilization, large series of specimens should be compared before attempting to establish specific distinctions.

Some additional specimens, from a block consisting principally of serpentine, differ from the ordinary Grenville specimens in the more highly crystalline character of the calc-spar and serpentine, in the development of certain minute dendritic crystallizations, and in the apparent compression and distortion of the fossils. These appearances I regard as due to the mode of preservation, rather than to any original differences; certain portions less altered than the others presenting the ordinary typical characters.

Two slices of limestone from the British Islands, and supposed to be Laurentian, have been compared with the Canadian limestones above noticed. One is a serpentine-marble from Tyree. It appears to be fragmental like some of the Laurentian limestones of Canada, and may contain fragments of *Eozoön*. The other is from Ireland,* and presents what I regard as traces of organic structure, but not, in so far as can be made out, of the character of *Eozoön*. Both of these limestones deserve careful microscopic examination.

NOTES ON THE STRUCTURE AND AFFINITIES OF EOZOÖN CANADENSE.

By W. B. CARPENTER, M.D., F.R.S., F.G.S.

[In a Letter to Sir William E. Logan, LL.D., F.R.S., F.G.S.]

The careful examination which I have made—in accordance with the request you were good enough to convey to me from Dr. Dawson, and to second on your own part—into the structure of

[* Given by mistake as "Iona" in the Journal of the Geological Society. It is a specimen of Connemara marble from the collection of Dr. Hunt, who supposed it to be Laurentian. See note on page 93, and for further observations on this marble see below, p. 128.]

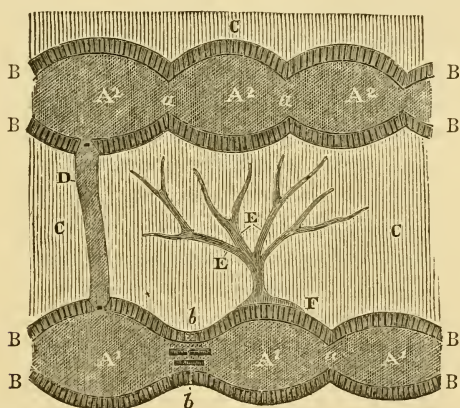
the very extraordinary fossil which you have brought from the Laurentian rocks of Canada,* enables me most unhesitatingly to confirm the sagacious determination of Dr. Dawson as to its Rhizopod characters and Foraminiferal affinities, and at the same time furnishes new evidence of no small value in support of that determination. In this examination I have had the advantage of a series of sections of the fossil much superior to those submitted to Dr. Dawson; and also of a large series of decalcified specimens, of which Dr. Dawson had only the opportunity of seeing a few examples after his memoir had been written. These last are peculiarly instructive; since in consequence of the complete infiltration of the chambers and canals, originally occupied by the sarcod-body of the animal, by mineral matter insoluble in dilute nitric acid, the removal of the calcareous shell brings into view not only the internal casts of the chambers, but also casts of the interior of the 'canal-system' of the 'intermediate' or 'supplemental skeleton,' and even casts of the interior of the very fine parallel tubuli which traverse the proper walls of the chambers. And, as I have remarked elsewhere,† "such casts place before us far more exact representations of the configuration of the animal body, and of the connexions of its different parts, than we could obtain even from living specimens by dissolving away their shells with acid; its several portions being disposed to heap themselves together in a mass when they lose the support of the calcareous skeleton."

The additional opportunities I have thus enjoyed will be found, I believe, to account satisfactorily for the differences to be observed between Dr. Dawson's account of the *Eozoön* and my own. Had I been obliged to form my conclusions respecting its structure only from the specimens submitted to Dr. Dawson, I should very probably have seen no reason for any but the most complete accordance with his description: while if Dr. Dawson had enjoyed the advantage of examining the entire series of preparations which have come under my own observation, I feel confident that he would have anticipated the corrections and additions which I now offer.

* The specimens submitted to Dr. Carpenter were taken from a block of *Eozoön* rock, obtained in the Petite Nation Seigniory, too late to afford Dr. Dawson an opportunity of examination. They are from the same horizon as the Grenville specimens.—W. E. L.

† Introduction to the Study of the Foraminifera, p. 10.

Although the general plan of growth described by Dr. Dawson, and exhibited in his photographs of vertical sections of the fossil, is undoubtedly that which is typical of *Eozoön*, yet I find that the acervuline mode of growth, also mentioned by Dr. Dawson, very frequently takes its place in the more superficial parts, where the chambers, which are arranged in regular tiers in the laminated portions, are heaped one upon another without any regularity, as is particularly well shown in some decalcified specimens which I have myself prepared from the slices last put into my hands. I see no indication that this departure from the normal type of structure has resulted from an injury; the transition from the regular to the irregular mode of increase not being abrupt, but gradual. Nor should I be disposed to regard it as a monstrosity; since there are



4. DIAGRAM ILLUSTRATING THE STRUCTURE OF EOZOÖN.

A', A', A'. Three chambers of one layer, communicating with each other directly at *a*, and by three passages through a shelly partition at *b*.

A², A², A². Three chambers of a more superficial layer.

B, B, B. Proper wall of the chambers, composed of finely tubular shell-substance.

C, C, C. Intermediate or supplemental skeleton, traversed by D, a stolon of communication between two chambers of different layers, and by E, E, a canal-system originating in the lacunar space F.

many other *Foraminifera* in which an originally definite plan of growth gives place, in a later stage, to a like acervuline piling-up of chambers.

In regard to the form and relations of the chambers, I have little

to add to Dr. Dawson's description. The evidence afforded by their internal casts concurs with that of sections, in showing that the segments of the sarcode-body, by whose aggregation each layer was constituted, were but very incompletely divided by shelly partitions; this incomplete separation (as Dr. Dawson has pointed out) having its parallel in that of the secondary chambers in *Carpen-teria*. But I have occasionally met with instances in which the separation of the chambers has been as complete as it is in Foraminifera generally; and the communication between them is then established by several narrow passages exactly corresponding with those which I have described and figured in *Cycloclypeus*.*

The mode in which each successive layer originates from the one which had preceded it, is a question to which my attention has been a good deal directed; but I do not as yet feel confident that I have been able to elucidate it completely. There is certainly no regular system of apertures for the passage of stolons giving origin to new segments, such as are found in all ordinary Polythalamous Foraminifera, whether their type of growth be rectilinear, spiral, or cyclical; and I am disposed to believe that where one layer is separated from another by nothing else than the proper walls of the chambers,—which, as I shall presently show, are traversed by multitudes of minute tubuli giving passage to pseudopodia,—the coalescence of these pseudopodia on the external surface would suffice to lay the foundation of a new layer of sarcodic segments. But where an intermediate or supplemental skeleton, consisting of a thick layer of solid calcareous shell, has been deposited between two successive layers, it is obvious that the animal body contained in the lower layer of chambers must be completely cut off from that which occupies the upper, unless some special provision exist for their mutual communication. Such a provision I believe to have been made by the extension of bands of sarcode, through canals left in the intermediate skeleton, from the lower to the upper tier of chambers. For in such sections as happen to have traversed thick deposits of the intermediate skeleton, there are generally found passages distinguished from those of the ordinary canal-system by their broad flat form, their great transverse diameter, and their non-ramification. One of these passages I have distinctly traced to a chamber, with the cavity of which it communicated through two or three apertures in its proper wall

* *Op. cit.*, p. 294.

(plate, figure 3. c); and I think it likely that I should have been able to trace it at its other extremity into a chamber of the superjacent tier, had not the plane of the section passed out of its course. Ribband-like casts of these passages are often to be seen in decalcified specimens, traversing the void spaces left by the removal of the thickest layers of the intermediate skeleton.

But the organization of a new layer seems to have not unfrequently taken place in a much more considerable extension of the sarcode-body of the pre-formed layer; which either folded back its margin over the surface already consolidated, in a manner somewhat like that in which the mantle of a *Cypræa* doubles back to deposit the final surface-layer of its shell, or sent upwards wall-like lamellæ, sometimes of very limited extent, but not unfrequently of considerable length, which, after traversing the substance of the shell, like trap-dykes in a bed of sandstone, spread themselves out over its surface. Such, at least, are the only interpretations I can put upon the appearances presented by decalcified specimens. For on the one hand, it is frequently to be observed that two bands of serpentine (or other infiltrated mineral), which represent two layers of the original sarcode-body of the animal, approximate to each other in some part of their course, and come into complete continuity; so that the upper layer would seem at that part to have had its origin in the lower. Again, even where these bands are most widely separated, we find that they are commonly held together by vertical lamellæ of the same material, sometimes forming mere tongues, but often running to a considerable length. That these lamellæ have not been formed by mineral infiltration into accidental fissures in the shell, but represent corresponding extensions of the sarcode-body, seems to me to be indicated not merely by the characters of their surface, but also by the fact that portions of the canal-system may be occasionally traced into connection with them.

Although Dr. Dawson has noticed that some parts of the sections which he examined present the fine tubulation characteristic of the shells of the Nummuline Foraminifera, he does not seem to have recognized the fact, which the sections placed in my hands have enabled me most satisfactorily to determine,—that the proper walls of the chambers everywhere present the fine tubulation of the Nummuline shell (plate, figs. 3, 6); a point of the highest importance in the determination of the affinities of *Eozoön*. This tubulation, although not seen with the clearness with which it is to be discerned

in recent examples of the Nummuline type, is here far better displayed than it is in the majority of fossil Nummulites, in which the tubuli have been filled up by the infiltration of calcareous matter, rendering the shell-substance nearly homogeneous. In *Eozoön* these tubuli have been filled up by the infiltration of a mineral different from that of which the shell is composed, and therefore not coalescing with it; and the tubular structure is consequently much more satisfactorily distinguishable. In decalcified specimens, the free margins of the casts of the chambers are often seen to be bordered with a delicate white glistening fringe; and when this fringe is examined with a sufficient magnifying power, it is seen to be made up of a multitude of extremely delicate *aciculi*, standing side by side like the fibres of asbestos. These, it is obvious, are the internal casts of the fine tubuli which perforated the proper wall of the chambers, passing directly from its inner to its outer surface; and their presence in this situation affords the most satisfactory confirmation of the evidence of that tubulation afforded by thin sections of the shell-wall.

The successive layers, each having its own proper wall, are often superposed one upon another without the intervention of any supplemental or intermediate skeleton such as presents itself in all the more massive forms of the Nummuline series; but a deposit of this form of shell-substance, readily distinguishable by its homogeneousness from the finely tubular shell immediately investing the segments of the sarcode-body, is the source of the great thickening which the calcareous zones often present in vertical sections of *Eozoön*. The presence of this intermediate skeleton has been correctly indicated by Dr. Dawson; but he does not seem to have clearly differentiated it from the proper wall of the chambers. All the tubuli which he has described belong to that canal-system which, as I have shown,* is limited in its distribution to the intermediate skeleton, and is expressly destined to supply a channel for its nutrition and augmentation. Of this canal-system, which presents most remarkable varieties in dimensions and distribution, we learn more from the casts presented by decalcified specimens, than from sections, which only exhibit such parts of it as their plane may happen to traverse. Illustrations from both sources, giving a more complete representation of it than Dr. Dawson's figures afford, have been prepared from the additional specimens placed in my hands (plate, figure 7).

* *Op. cit.*, pp. 50, 51.

It does not appear to me that the canal-system takes its origin directly from the cavity of the chambers. On the contrary, I believe that, as in *Calcarina* (which Dr. Dawson has correctly referred to as presenting the nearest parallel to it among recent *Foraminifera*), they originate in lacunar spaces on the outside of the proper walls of the chambers, into which the tubuli of those walls open externally; and that the extensions of the sarcode-body which occupied them were formed by the coalescence of the pseudopodia issuing from those tubuli.*

It seems to me worthy of special notice, that the canal-system, wherever displayed in transparent sections, is distinguished by a yellowish-brown coloration, so exactly resembling that which I have observed in the canal-system of recent *Foraminifera* (as *Polystomella* and *Calcarina*) in which there were remains of the sarcode-body, that I cannot but believe the infiltrating mineral to have been dyed by the remains of sarcode still existing in the canals of *Eozoön* at the time of its consolidation. If this be the case, the preservation of this color seems to indicate that no considerable metamorphic action has been exerted upon the rock in which this fossil occurs. And I should draw the same inference from the fact that the organic structure of the shell is in many instances even more completely preserved than it usually is in the Nummulites and other *Foraminifera* of the Nummulitic limestone of the early Tertiaries.

To sum up,—That the *Eozoön* finds its proper place in the Foraminiferal series, I conceive to be conclusively proved by its accordance with the great types of that series, in all the essential characters of organization;—namely, the structure of the shell forming the proper wall of the chambers, in which it agrees precisely with *Nummulina* and its allies; the presence of an intermediate skeleton and an elaborate canal-system, the disposition of which reminds us most of *Calcarina*; a mode of communication of the chambers when they are most completely separated, which has its exact parallel in *Cycloclypeus*; and an ordinary want of completeness of separation between the chambers, corresponding with that which is characteristic of *Carpenteria*.

There is no other group of the Animal Kingdom to which *Eozoön* presents the slightest structural resemblance; and to the suggestion that it may have been of kin to Nullipore, I can offer the most distinct negative reply, having many years ago carefully studied

* *Op. cit.*, p. 221.

the structure of that stony Alga, with which that of *Eozoön* has nothing whatever in common.

The objections which not unnaturally occur to those familiar with only the ordinary forms of *Foraminifera*, as to the admission of *Eozoön* into the series, do not appear to me of any force. These have reference in the first place to the great *size* of the organism; and in the second, to its exceptional mode of growth.

1. It must be borne in mind that all the *Foraminifera* normally increase by the continuous gemmation of new segments from those previously formed; and that we have, in the existing types, the greatest diversities in the extent to which this gemmation may proceed. Thus in the *Globigerinæ*, whose shells cover to an unknown thickness the sea-bottom of all that portion of the Atlantic Ocean which is traversed by the Gulf-stream, only eight or ten segments are ordinarily produced by continuous gemmation; and if new segments are developed from the last of these, they detach themselves so as to lay the foundation of independent *Globigerinæ*. On the other hand in *Cyclodypeus*, which is a discoidal structure attaining two and a quarter inches in diameter, the number of segments formed by continuous gemmation must be many thousand. Again, the *Receptaculites* of the Canadian Silurian rocks, shown by Mr. Salter's drawings* to be a gigantic Orbitolite, attains a diameter of twelve inches; and if this were to increase by vertical as well as by horizontal gemmation (after the manner of *Tinoporus* or *Orbitoides*) so that one discoidal layer would be piled on another, it would form a mass equalling *Eozoön* in its ordinary dimensions. To say, therefore, that *Eozoön* cannot belong to the *Foraminifera* on account of its gigantic size, is much as if a botanist who had only studied plants and shrubs were to refuse to admit a tree into the same category. The very same continuous gemmation which has produced an *Eozoön* would produce an equal mass of independent *Globigerinæ*, if after eight or ten repetitions of the process, the new segments were to detach themselves.

It is to be remembered, moreover, that the largest masses of sponges are formed by continuous gemmation from an original Rhizopod segment; and that there is no *à priori* reason why a Foraminiferal organism should not attain the same dimensions as a Poriferal one,—the intimate relationship of the two groups, notwithstanding the difference between their skeletons, being unquestionable.

* First Decade of Canadian Fossils, pl. x.

2. The difficulty arising from the zoophytic plan of growth of *Eozoön* is at once disposed of by the fact that we have in the recent *Polytrema* (as I have shown, *op. cit.* p. 235) an organism nearly allied in all essential points of structure to *Rotalia*, yet no less aberrant in its plan of growth, having been ranked by Lamarek among the Millepores. And it appears to me that *Eozoön* takes its place quite as naturally in the Nummuline series as *Polytrema* in the Rotaline. As we are led from the typical *Rotalia*, through the less regular *Planorbulina*, to *Tinoporus*, in which the chambers are piled up vertically, as well as multiplied horizontally, and thence pass by an easy gradation to *Polytrema*, in which all regularity of external form is lost; so may we pass from the typical *Operculina* or *Nummulina*, through *Heterostegina* and *Cycloclypeus* to *Orbitoides*, in which, as in *Tinoporus*, the chambers multiply both by horizontal and by vertical gemmation; and from *Orbitoides* to *Eozoön* the transition is scarcely more abrupt than from *Tinoporus* to *Polytrema*.

The general acceptance, by the most competent judges, of my views respecting the primary value of the characters furnished by the intimate structure of the shell, and the very subordinate value of plan of growth, in the determination of the affinities of Foraminifera, renders it unnecessary that I should dwell further on my reasons for unhesitatingly affirming the Nummuline affinities of *Eozoön* from the microscopic appearances presented by the proper wall of its chambers, notwithstanding its very aberrant peculiarities; and I cannot but feel it to be a feature of peculiar interest in geological inquiry, that the true relations of by far the earliest fossil yet known should be determinable by the comparison of a portion which the smallest pin's head would cover, with organisms at present existing.

I need not assure you of the pleasure which it has afforded me to be able to co-operate with Dr. Dawson and yourself in this development of my previous researches; but I may venture to add the anticipation that the discovery of *Eozoön* is the first of many discoveries in the Laurentian series, which will vastly add to our knowledge of the primæval life of our globe. And I am strongly inclined also to concur in the belief expressed by Dr. Dawson in a private letter to myself, that a more thorough examination of some of the Silurian fossils (such as *Stromatopora*) hitherto ranked among corals and sponges, will prove that they are really, like *Eozoön* and *Receptaculites*, gigantic *Foraminifera*.

EXPLANATION OF THE PLATE,

ILLUSTRATING THE STRUCTURE AND AFFINITIES OF *EOZOÖN CANADENSE*.

Of the figures here given, 1, 3, 6*a*, 6*b*, and 7, are selected from two plates given by Dr. Carpenter to illustrate his paper; while 2, 4, and 5, are from the plates accompanying Dr. Dawson's description, and are from drawings by Mr. Horace H. Smith, the artist of the Survey.

The figures, with the exception of 7, are from transparent sections of specimens in which the original shell was well preserved, and its minutest cavities infiltrated with serpentine. Figure 7 is from a specimen from which the calcareous skeleton was removed by an acid, and represents the internal casts of the tubes, as seen by reflected light.

- Fig. 1. Vertical section of regularly stratified portion of *Eozoön* showing the ordinarily continuous connection of the chambers of each stratum; magnified 10 diameters.
2. Horizontal section of *Eozoön* from Grenville, magnified 25 diameters; *a*, systems of tubuli; *b*, secondary chamber.
3. Portions of two chambers of different layers, showing at *a*, *a*, the proper walls of their chambers; at *b*, *b*, the intermediate skeleton; and at *c*, *c*, a stoloniferous passage: magnified 25 diameters.
4. One of the systems of tubuli cut transversely; magnified 100 diameters.
5. Part of a system of tubuli cut transversely; magnified 200 diameters.
6. Portions of the proper wall of the chambers, showing its Nummuline tubulation, as seen at *a* in longitudinal, and at *b* in transverse section; magnified 100 diameters.
7. Cast of the interior of canal-system; an entire group magnified 10 diameters.

ON THE MINERALOGY OF *EOZOÖN CANADENSE*.*

By T. STERRY HUNT, M.A., F.R.S.

The remains of *Eozoön Canadense*, a Foraminiferal organism recently discovered in the Laurentian limestones of Canada, present an interesting subject of study, both to the mineralogist and geologist. For a zoological description of this organic form the reader is referred to the preceding descriptions by Dr. Dawson and Dr. Carpenter.

The details of structure have been preserved by the introduction of certain mineral silicates, which have not only filled up the

[* See preliminary notice, Silliman's Journal [2] xxxvii, 431.]



EOZOON CANADENSE DAWSON.

chambers, cells, and canals left vacant by the disappearance of the animal matter, but have in very many cases been injected into the tubuli, filling even their smallest ramifications. These silicates have thus taken the place of the original sarcode, while the calcareous septa remain. It will then be understood that when the replacement of the *Eozoön* by silicates is spoken of, this is to be understood of the soft parts only; since the calcareous skeleton is preserved, in most cases, without any alteration. The vacant spaces left by the decay of the sarcode may be supposed to have been filled by a process of infiltration, in which the silicates were deposited from solution in water, like the silica which fills up the pores of wood in the process of silicification. The replacing silicates, so far as yet observed, are a white pyroxene, a pale-green serpentine, and a dark-green aluminomagnesian mineral, which is allied in composition to chlorite and to pyrosclerite, and which I have referred to loganite. The calcareous septa in the last case are found to be dolomitic, but in the other instances are nearly pure carbonate of lime. The relations of the carbonate and the silicates are well seen in thin sections under the microscope, especially by polarized light. The calcite, dolomite, and pyroxene exhibit their crystalline structure to the unaided eye; and the serpentine and loganite are also seen to be crystalline when examined with the microscope. When portions of the fossil are submitted to the action of an acid, the carbonate of lime is dissolved, and a coherent mass of serpentine is obtained, which is a perfect cast of the soft parts of the *Eozoön*. The form of the sarcode which filled the chambers and cells is beautifully shown, as well as the connecting canals and the groups of tubuli; these latter are seen in great perfection upon surfaces from which the carbonate of lime has been partially dissolved. Their preservation is generally most complete when the replacing mineral is serpentine, although very perfect specimens are sometimes found in pyroxene. The crystallization of the latter mineral appears, however, in most cases to have disturbed the calcareous septa.

Serpentine and pyroxene are generally associated in these specimens, as if their disposition had marked different stages of a continuous process. At the Calumet, one specimen of the fossil exhibits the whole of the sarcode replaced by serpentine; while, in another one from the same locality, a layer of pale green translucent serpentine occurs in immediate contact with the white pyroxene. The calcareous septa in this specimen are very thin, and are

transverse to the plane of contact of the two minerals; yet they are seen to traverse both the pyroxene and the serpentine without any interruption or change. Some sections exhibit these two minerals filling adjacent cells, or even portions of the same cell, a clear line of division being visible between them. In the specimens from Grenville, on the other hand, it would seem as if the development of the *Eozoön* (considerable masses of which were replaced by pyroxene) had been interrupted, and that a second growth of the animal, which was replaced by serpentine, had taken place upon the older masses, filling up their interstices.

The results of the chemical examination of these fossils from different localities may now be given:—

I. A specimen of *Eozoön* from the Calumet, remarkable for the regularity of its laminated arrangement, gave to warm acetic acid 27.0 per cent of soluble matter, consisting of carbonate of lime 97.1, carbonate of magnesia 2.9; = 100.

II. Another specimen of the fossil, from Grenville, replaced by pyroxene, yielded in the same way 12.0 per cent of soluble matter, which was composed of carbonate of lime 98.7, carbonate of magnesia 1.3; = 100.

III. In this specimen of the fossil, which adjoined the last, serpentine was the replacing mineral. The soluble portion from this equalled 47.0 per cent, and consisted of carbonate of lime 96.0, carbonate of magnesia 4.0; = 100. It thus appears that the septa in these specimens of *Eozoön* are nearly pure carbonate of lime. The somewhat larger proportion of magnesia from the last is due to the use, as a solvent, of dilute nitric acid, which slightly attacked the serpentine.

The pyroxene of the above specimens is a very pure silicate of lime and magnesia; that from I gave, by analysis, silica 54.90, lime 27.67, magnesia 16.76, volatile matter 0.80; = 100.13. A partial analysis of the pyroxene from II yielded lime 28.3, magnesia 13.8. This specimen was interpenetrated with serpentine, amounting to about 10.0 per cent, which was first removed by the successive action of heated sulphuric acid and dilute soda-ley. The serpentine from III yielded silica 42.85, magnesia 41.68, protoxide of iron 0.67, water 13.89; = 99.09. As already mentioned, this serpentine had lost a little magnesia from the action of nitric acid. A similar serpentine from the Calumet, associated with the *Eozoön*, gave silica 41.20, magnesia 43.52, protoxide of iron 0.80, water

15.40; = 100.92. These serpentines from the Laurentian limestones are remarkable for their freedom from iron-oxide, for their large amount of water, and their low specific gravity.*

Specimens of *Eozoön* from Burgess differ from the foregoing in the composition both of the replacing material and septa. The latter consist of a somewhat ferriferous dolomite, the analysis of which was made upon portions mechanically separated from the enclosed silicate: it yielded carbonate of magnesia 40.7, carbonate of lime, with a little peroxide of iron, 59.0; = 99.7. The septa of the specimen from this locality are in some parts more than 3.0 millimetres in thickness, and exhibit the chambers, cells, and septal orifices; but no tubuli are seen. The replacing material has the hardness of serpentine, for which it was at first mistaken. Its color is blackish-green; but olive-green in thin sections, when it is seen by transmitted light to be crystalline in texture. Its fracture is granular, and its lustre feebly shining. It is decomposed by heated sulphuric acid, and was thus analyzed, yielding the result I. The centesimal composition of the soluble portion is given under II.

	I.	II.	III.
Silica	33.75	35.14	36.50
Alumina.....	9.75	10.15	10.80
Magnesia	30.24	31.47	28.20
Protoxide of iron.....	8.19	8.60	9.54
Water.....	14.08	14.64	14.62
Insoluble sand.....	2.50	..	..
	<hr/>	<hr/>	<hr/>
	98.51	100.00	99.66

The silicate which here takes the place of the pyroxene and serpentine observed in the other specimens of *Eozoön* is one of frequent occurrence in the Laurentian limestones, and appears to constitute a distinct species, which I long since described under the name of loganite, and which occurs at the Calumet in dark brown prismatic crystals.† I have since observed a similar mineral in two other localities besides the one here noticed. The result III, which is placed by the side of the analysis of the Burgess fossil, was obtained with a greenish-grey sparry prismatic variety from North Elmsley, having a hardness of 3.0, and a specific gravity of

* See my descriptions, Silliman's Journal [2] xxvi, 236.

† Phil. Mag., 4th ser., vol. ii, p. 65.

2-539. These hydrous aluminomagnesian silicates, which I have included under the name of loganite,* are related to chlorite and to pyrosclerite in composition ; but these last are distinguished from it by their eminently foliated micaceous structure.

When examined under the microscope, the loganite which replaces the *Eozoön* of Burgess, shows traces of cleavage-lines, which indicate a crystalline structure. The grains of insoluble matter found in the analysis, chiefly of quartz-sand, are distinctly seen as foreign bodies imbedded in the mass, which is moreover marked by lines apparently due to cracks formed by a shrinking of the silicate, and subsequently filled by a further infiltration of the same material. This arrangement resembles on a minute scale that of septaria. Similar appearances are also observed in the serpentine which replaces the *Eozoön* of Grenville, and also in a massive serpentine from Burgess, resembling this, and enclosing fragments of the fossil. In both of these specimens also grains of mechanical impurities are detected by the microscope ; they are however rarer than in the loganite of Burgess.

From the above facts it may be concluded that the various silicates which now constitute pyroxene, serpentine, and loganite were directly deposited in waters in the midst of which the *Eozoön* was still growing, or had only recently perished ; and that these silicates penetrated, enclosed, and preserved the calcareous structure precisely as carbonate of lime might have done. The association of the silicates with the *Eozoön* is only accidental ; and large quantities of them, deposited at the same time, include no organic remains. Thus, for example, there are found associated with the *Eozoön*-limestones of Grenville, massive layers and concretions of pure serpentine ; and a serpentine from Burgess has already been mentioned as containing only small broken fragments of the fossil. In like manner large masses of white pyroxene, often surrounded by serpentine, both of which are destitute of traces of organic structure, are found in the limestone at the Calumet. In some cases, however, the crystallization of the pyroxene has given rise to considerable cleavage-planes, and has thus obliterated the organic structures from masses which, judging from portions visible here and there, appear to have been at one time penetrated by the calcareous plates of *Eozoön*. Small irregular veins of crystalline calcite, and

* For a description of this and similar silicates, see *Geology of Canada*, p. 491.

of serpentine, are found to traverse* such pyroxene-masses in the Eozoön-limestone of Grenville.

As already mentioned in Sir W. E. Logan's description, it appears that great beds of the Laurentian limestones are composed of the ruins of the *Eozoön*. These rocks, which are white, crystalline, and mingled with pale-green serpentine, are similar in aspect to many of the so-called primary limestones of other regions. In most cases the limestones are non-magnesian, but one of them from Grenville was found to be dolomitic. The accompanying strata often present finely crystallized pyroxene, hornblende, phlogopite, apatite, and other minerals. These observations bring the formation of siliceous minerals face to face with life, and show that their generation was not incompatible with the contemporaneous existence and the preservation of organic forms. They confirm, moreover, the view which I some years since put forward, that these silicated minerals have been formed, not by subsequent metamorphism in deeply buried sediments, but by reactions going on at the earth's surface.† In support of this view, I have elsewhere referred to the deposition of silicates of lime, magnesia, and iron from natural waters, to the great beds of sepiolite in the unaltered Tertiary strata of Europe; to the contemporaneous formation of neolite (an alumino-magnesian silicate related to loganite and chlorite in composition); and to glauconite, which occurs not only in Secondary, Tertiary, and Recent deposits, but also, as I have shown, in Lower Silurian strata.‡ This hydrous silicate of protoxide of iron and potash, which sometimes includes a considerable proportion of alumina in its composition, has been observed by Ehrenberg, Mantell, and Bailey associated with organic forms in a manner which seems identical with that in which pyroxene, serpentine, and loganite occur with the *Eozoön* in the Laurentian limestones. According to the first of these observers, the grains of green-sand, or glauconite, from the Tertiary limestone of Alabama are casts of

* Recent examinations have shown that some of these masses encrusted with *Eozoön* replaced by serpentine, consist of crystalline pyrallolite (rensselaerite), which seems, like the other silicates, to have replaced the organic matter of the Rhizopod. Further examinations aided by the microscope, are however needed to determine with certainty the relations of the *Eozoön* to these masses of pyrallolite.

† Silliman's Journal [2] xxix, 284; xxxii, 286. Geology of Canada p. 577.

‡ Silliman's Journal [2] xxxiii, 277. Geology of Canada, p. 487.

the interior of Polythalamia, the glauconite having filled them by "a species of natural injection, which is often so perfect that not only the large and coarse cells, but also the very finest canals of the cell-walls and all their connecting tubes, are thus petrified and separately exhibited." Bailey confirmed these observations, and extended them. He found in various Cretaceous and Tertiary limestones of the United States, casts in glauconite, not only of *Foraminifera*, but of spines of *Echinus*, and of the cavities of corals. Besides, there were numerous red, green, and white casts of minute anastomosing tubuli, which, according to Bailey, resemble the casts of the holes made by burrowing sponges (*Cliona*) and worms. These forms are seen after the dissolving of the carbonate of lime by a dilute acid. He found, moreover, similar casts of *Foraminifera*, of minute mollusks, and of branching tubuli, in mud obtained from soundings in the Gulf-stream, and concluded that the deposition of glauconite is still going on in the depths of the sea.* Pourtales has followed up these investigations on the recent formation of glauconite in the Gulf-stream waters. He has observed its deposition also in the cavities of *Millepores*, and in the canals in the shells of *Balanus*. According to him, the glauconite grains formed in *Foraminifera* lose after a time their calcareous envelopes, and finally become "conglomerated into small black pebbles," sections of which still show under a microscope the characteristic spiral arrangement of the cells.†

It appears probable from these observations that glauconite is formed by chemical reactions in the ooze at the bottom of the sea, where dissolved silica comes in contact with iron-oxide rendered soluble by organic matter; the resulting silicate deposits itself in the cavities of shells and other vacant spaces. A process analogous to this in its results, has filled the chambers and canals of the Laurentian *Foraminifera* with other silicates; from the comparative rarity of mechanical impurities in these silicates, however, it would appear that they were deposited in clear water. Alumina and oxide of iron enter into the composition of loganite as well as of glauconite; but in the other replacing minerals, pyroxene and serpentine, we have only silicates of lime and magnesia, which were probably formed by the direct action of alkaline silicates, either

* Silliman's Journal [2] xxii, 280.

† Report of United States Coast-Survey, 1858, p. 248.

dissolved in surface-waters, or in those of submarine springs, upon the calcareous and magnesian salts of the sea-water. Experiments undertaken with the view of determining the precise conditions under which these and similar silicates may thus be formed, are now in progress.

APPENDIX TO DR. DAWSON'S PAPER (pages 99—111).

Since the above papers were published, I have had opportunities of examining slices and decalcified specimens of *Eozoön* from Petite Nation, the locality which afforded the specimens referred to by Dr. Carpenter (pages 112, 116), and I have much pleasure in adding my testimony to his observation of the distinctness of the proper wall of the chambers from the supplemental or intermediate skeleton, as exhibited in these specimens. In the specimens previously examined I could not distinctly ascertain that the structure of the proper wall had been preserved, except in a small fragment from Burgess, not certainly known to be of the same species with the specimens from Grenville. Although I believed that such a distinction must have existed, I could not affirm that it had been preserved. I therefore regard these additional structures, ascertained by Dr. Carpenter, as affording strong confirmation of the foraminiferal nature of *Eozoön*, and as indicating its high rank in the order of Foraminifera; while at the same time no more satisfactory guarantee for the correctness of the observations made here could be given, than the concurrence of one whose authority in such subjects is deservedly so high.

It is also gratifying to find in recent British publications,* notices to the effect that Mr. Sanford has found the structure of *Eozoön* in the Laurentian limestone of Ireland), the Connemara marble of the Binabola Mountains) already referred to on page 111. Mr. Sanford's specimens have been further examined by Prof. Rupert Jones, who says: "except that the serpentine replacing the sarcode is lighter than in specimens furnished by Sir William Logan, there is no real difference between the two." *Eozoön Canadense* will thus, in all probability, be found to be characteristic of the Laurentian, and possibly of a particular portion of that series on both sides of the Atlantic, and will become important to palæontologists as a means of recognizing rocks of this early life-zone. It would appear also that in Ireland as in Canada the remains of the creature have

* Geol. Mag., Nov. 1864; Reader, Feb. 25, 1865.

contributed largely to the formation of limestone, since Prof. Jones remarks that he has detected its structure abundantly in chips of 'Irish-green' marble from marble-works in London; and Mr. Sanford represents a somewhat extensive bed of limestone in the Binabola Mountains, as abounding in it throughout, though not always in a good state of preservation. J. W. D.

NOTES ON CERTAIN SPECIES OF NOVA-SCOTIAN FISHES.

BY J. MATTHEW JONES, F.L.S.

THE YELLOW PERCH.—*Perca flavescens*.

- Perca flavescens*.....Cuv. et Val., ii, p. 46.
 " "Rich., Faun. Bor. Amer., p. 1, pl. 74.
 " "Storer, Fishes of Mass., p. 5.
 " "DeKay, N. Y. Faun., p. 3, pl. 1, fig. 1.
 " "Holb., Ich. S. C., p. 2, pl. 1, fig. 1.
 " "Gunth., Cat. Fishes, i, p. 59.
Bodianus flavescens.....Mitch., Ph. Trans. N. Y., i, p. 421.

This fish is very common in the fresh waters of this province, and is similar in habit to the common perch of Europe. It is sold in the Halifax market during winter in small bunches of a dozen each at the rate of sixpence sterling per bunch, but it is not much esteemed as food.

Gunther, in his catalogue of the acanthopterygian fishes in the British Museum collection, states his belief, after an examination of the skeletons of this and the European *P. fluviatilis*, that they are merely varieties of one and the same species.

Its geographical distribution is extensive,—being found in nearly every part of North America.

SCULPIN.—*Cottus Grœnlandicus*.

- Cottus Grœnlandicus*Cuv. et Val., iv, p. 156.
 " "Rich. iii, pp. 46, 297, pl. 95, fig. 2.
 " "Storer, Fishes of Mass., p. 16.
 " "De Kay, p. 54, pl. 4, fig. 10.
 " "Gunth., Cat. Fishes, ii, p. 161.
 " *Scorpius*.....Fabr., Faun. Grœnl., p. 156.

This daring and voracious fish is very abundant on our shores. It cares but little for the presence of man, and will not leave its

position in the shallow water even when roughly touched with a boat-hook. It acts as a perfect scavenger at the fish-curing stations, gorging itself with the refuse thrown into the sea. Although somewhat repulsive in appearance and mode of life, it is remarkable for the beauty of its colors, which, in some specimens, are highly brilliant. The Rev. J. Ambrose informs me that a deep red-colored variety is found at St. Margaret's Bay, and is known to the fishermen under the name of 'deep-water sculpin.' The sculpin is very tenacious of life, existing for some time after removal from its native element.

NORWAY HADDOCK.—*Sebastes Norvegicus*.

<i>Sebastes Norvegicus</i>	Cuv. et Val., iv., p. 327, pl. 87.
" "	Yarrell, Brit. Fishes, i, p. 87.
" "	Rich., Faun. Bor. Amer., p. 52.
" "	Storer, Fishes of Mass., p. 26.
" "	De Kay, p. 60, pl. 4, fig. 2.
" "	Gunth., Cat. Fishes, ii, p. 95.
<i>Perca marina</i>	Pennant, Brit. Zool., iii, p. 226.
<i>Holocentrus Norvegicus</i>	Lacep., iv, p. 390.

This beautiful fish, which vies in brilliancy of color with the gaudy-coated denizens of the tropical seas, is by no means uncommon on our coast during winter and summer. It occurs more frequently, perhaps, during the winter season. As the minute young has been procured from the stomach of a cod caught in the vicinity of Halifax, it is more than probable that it breeds with us. When fishing for cod, it is taken on the banks several miles from shore, and is known in the Halifax market as the 'John-a-Dory,' where it sells at the rate of two pence sterling each, but is never exhibited for sale in any quantity. The Greenland and Arctic seas appear to be the proper habitat of this species. I have procured the opercular spines from the Kjoekkenmoedding on our Atlantic coast.

SPOTTED WRYMOUTH.—*Cryptacanthodes maculatus*.

<i>Cryptacanthodes maculatus</i>	Storer, Fishes of Mass., p. 28.
" "	Gunth., Cat. Fishes, iii, p. 291.

A fine example of this rare fish was taken while swimming with its head out of water near the Commercial Wharf, Halifax, on the 14th of June 1860, and was presented to me by Andrew Downs, Esq. It was perfectly white in color, and had the exact appearance of a cast in plaster of Paris. This white color changed—after it had been some time in spirits—to a light brown about the body,

but the head still retains its original plaster hue. Dr. Storer appears to have been the original discoverer of this curious fish on the Atlantic coast of America.¹

The following is a brief description of the dimensions, &c. of the specimen in my collection :

Extent, 33 inches. Depth at the deepest part across vent $2\frac{1}{2}$ inches ; at caudal extreme, 9 lines. Diameter of body at base of pectorals, 3 inches. Extent of head, $4\frac{1}{4}$ inches ; breadth at broadest part, the juncture with the neck, $4\frac{1}{2}$ inches ; depth, from summit to extended bony point beneath, $3\frac{1}{2}$ inches ; circumference over expanded gill-covers, $11\frac{1}{2}$ inches. Horizontal gape of mouth, $2\frac{3}{4}$ inches. Lower jaw 4 lines in advance of upper. Teeth conical, two rows in lower jaw curved inwards and extending outwards at chin ; four rows in upper jaw, the third and fourth of which are incomplete. Palatines, armed with small teeth posteriorly. Lips, wide, protruding from either side of divisional ridge to posterior corner. Snout abrupt, indented at extreme. Two triangular fleshy processes occur on either side of the nasal bone. Eyes, $9\frac{1}{2}$ lines distant from each other, diameter $4\frac{1}{2}$ lines. An elevated bony ridge commences immediately above the eyes, and runs back for 4 lines, then rising gradually to the summit of the caput 3 inches from chin-point, and descending again to postextreme of head. A deepened pit-like depression of the form of the eye occurs behind each eye and a smaller pit between them in advance, situate in the groove formed by the bony ridge above the eyes. The bony ridges are distant from each other at widest part, 8 lines. A bony elevated ridge also occurs in front of the eyes. Anus about 3 lines in advance of anal fin. The branchiostegous rays are much inflated, causing the gill-covers to appear as if severed from the head. The dorsal and anal fins are higher at posterior extreme close to the caudal, the former having rays an inch long near its termination, and its commencement partially hid in a groove. The pectorals are 5 lines in extent, having a basal width of $8\frac{1}{2}$ lines ; they are rounded, and the eight primal rays (with the exception of the first) jointed about 2 or 3 lines from their tips. The caudal is 2 inches 8 lines in extent, having a spread of 2 inches.

MACKAREL.—*Scomber vernalis*.

Scomber vernalis.....DeKay, p. 101, pl. 12, fig. 34.

“ “Cuv. et. Val., viii, p. 48.

“ “Storer, Fishes of Mass., p. 41.

Scomber scomber.....	Yarrell, Brit. Fishes, ed. 2, i, p. 137.
“ “	Owen, Osteol. Cat., i, p. 61.
“ “	Gunth., Cat. Fishes, vol. ii, p. 357.

As with the common herring of this coast, I have every reason to believe that this fish is identical with the European species, and must adhere to such opinion until satisfactory evidence is shown to prove the contrary. Gunther in his catalogue even includes *S. grex* under the same head; but as I have not had an opportunity of examining one of this latter species, I am unable to speak as to the similarity which exists between them. The shores, harbors, and inlets of this province, particularly on the eastern and northern coasts, are annually visited by vast multitudes of the common mackarel, some of which are smaller and others larger than the medium-sized individuals. They are classed by merchants and fishermen as of three kinds:—No. 1, the largest and fattest; No. 2, the medium sized; and No. 3, the smallest. The habits of the mackarel are very capricious: some seasons it visits us in such vast abundance that the waters literally swarm with them; while in others, loud complaints are heard of their scarcity. Many are the reasons given to account for this singular habit; but no satisfactory conclusion can be reached until accurate observers on different parts of the coast take cognizance of the abundance or scarcity of their usual food during the time of their visit, and also of the temperature of the water, whether influenced by the warm current of the Gulf stream, or the colder waters of the Arctic current. Much remains for the investigation of the naturalist ere a true solution can be given to the mystery which hangs around the periodical appearance of marine fishes on our shores; and it must ever be a source of regret that some of our better-educated fishermen do not put their knowledge of the habits of fish to advantage by communicating any facts which would tend to throw light upon so interesting a subject.

From the middle of September to the end of October, appears to be the season of the best mackarel-fishing on our eastern coast, the larger kind being generally more abundant towards the close of the latter month. About the middle of June the spawn is generally ripe for depositing. Along the coast it is said that mackarel prove poisonous to pigs, but I have no facts to verify such an assertion. This fish is also supposed to be free from disease of any kind. Some years ago a fisherman at Prospect near Halifax was spearing for eels in mid-winter through the ice near shore, in the sandy mud,

and to his surprise caught a mackarel which appeared half torpid, and had its eyes covered with a filmy substance. Was this fish hibernating in the mud, or what could have brought it into such position at a time of year when its fellows were supposed to be away at some distance in the deep?

To show the extent to which the mackarel-fishery is carried on in our Province, I may state that in the year 1860, 49,748 barrels of mackarel were cured by our fishermen. But this is nothing in comparison to the total amount taken off the coast by United States fishermen and others who resort to these grounds in the season in their large and well-appointed craft, with more tackle than our fishermen possess. Specimens of No. 1 mackarel often attain large dimensions: one taken in the harbor of Port Mulgrave in September 1861, weighed two lbs., and measured 17 inches in length.

TUNNY.—*Thynnus vulgaris*.

Thynnus vulgaris.....	Cuv. et Val., viii, p. 58, pl. 210.
“ “	Yarrell, Brit. Fishes, i, p. 150.
“ “	Storer, Fishes of Mass., p. 47.
“ thynnus.....	Gunth., Cat., ii, p. 362.
Scomber thynnus.....	Don., Brit. Fishes, i, pl. 5.
“ “	Risso., Ich. Nice, p. 163.

The tunny is very common on our eastern coast during the summer months, and is known to the fishermen as the ‘albicore.’ The Rev. John Ambrose informs me that it visits St. Margaret’s Bay regularly every summer, several specimens being taken and rendered down for oil. They have been especially abundant this autumn (1864) in that locality.

SWORD-FISH.—*Xiphias gladius*.

Xiphias gladius.....	Risso., Ich. Nice, p. 99.
“ “	Cuv. et Val., viii, p. 255, pl. 225, 226.
“ “	Storer, Fishes of Mass., p. 51.
“ “	DeKay, p. 111, pl. xxvi, fig. 79.
“ “	Yarrell, Brit. Fishes, i, p. 164.

The sword-fish is by no means common on our coast, and only makes its appearance at intervals in our harbors and bays. One was taken last year in Bedford Basin, at the head of Halifax Harbor.

BUTTERFISH.—*Gunnellus vulgaris*.

<i>Gunnellus vulgaris</i>	Nilss., Skand. Faun., iv, p. 200.
“ <i>mucronatus</i>	DeKay, p. 153, pl. 12, fig. 36.
“ “ 	Cuv. et Val., xi, p. 427.
<i>Blennius gunnellus</i>	Rich., Faun. Bor. Amer., p. 91.
“ “ 	Lacep., ii, p. 503.
<i>Centronotus gunnellus</i>	Gunth., Cat. Fishes, iii, p. 285.
“ “ 	Bloch., Schn., p. 167.
<i>Murœnoides guttata</i>	Storer, Fishes of Mass., p. 65.

In the transactions of the Nova Scotian Institute of Natural Science (Part i, p. 50) I described this species from specimens forwarded to me by the Rev. J. Ambrose, who procured them with the dredge, in twelve to fourteen fathoms water, at the entrance of St. Margaret's Bay, in August 1860. I find that they are common on the coast, and afford food for the more voracious ground-feeders. DeKay's *G. mucronatus* does not coincide in color with the present species; but as it particularly corresponds in all other respects, I scarcely consider this variation a sufficient reason for disputing its identity, as all ichthyologists are aware how many familiar forms vary in the color of their markings, although beyond all doubt belonging to the same species.

WOLF-FISH.—*Anarrhicas lupus*.

<i>Anarrhicas lupus</i>	Linn., Syst., i, p. 430.
“ “ 	Fabr., Faun. Grœnl., p. 138, n. 97.
“ “ 	Lacep., ii, pp. 299, 300, pl. 9, fig. 2.
“ “ 	Rich., Faun. Bor. Amer., p. 95.
“ “ 	Yarrell, Brit. Fishes, ed. 3, ii., p. 384.
“ “ 	Gunth., Brit. Mus. Cat., iii, p. 208.
“ “ 	DeKay, p. 158, pl. 16, fig. 43.
“ “ 	Nilss., Skand. Faun., iv, p. 208.
“ <i>maculatus</i>	Bloch., Schn., p. 496.

A very common fish in our waters, and perhaps the most voracious of all. When taken from the water it is covered with a thick coating of slime, which renders it difficult to be taken hold of. In February 1863, when examining the Greenland shark (*Scymnus borealis*) which had been taken by some of our fishermen, I observed two of these wolf-fish, of good size, protruding from its mouth, the shark having disgorged them after its capture.

ANGLER.—*Lophius piscatorius*.

<i>Lophius piscatorius</i>	Linn., Syst., i, p. 402.
“ “ 	Cuv. et Val., xii, p. 344, pl. 362.

- Lophius piscatorius* Nilss., Skand. Faun., p. 245.
 " " Gunth., Cat. Fishes, iii. p. 179.
 " " Rich., Faun. Bor. Amer., p. 103.
 " " Storer, Fishes of Mass., pp. 71, 404.
 " *Americanus* DeKay, p. 162, pl. 28, fig. 87.

This is not an uncommon fish, although I have only had an opportunity of examining one specimen, which was forwarded by the Rev. J. Ambrose from St. Margaret's Bay.

BERGALL.—*Ctenolabrus burgall*.

- Ctenolabrus burgall* Gunth., Cat. Fishes, iv. p. 90.
 " *cœruleus* DeKay, p. 172, pl. 29, fig. 93.
Crenilabrus burgall Storer, Fishes of Mass., p. 78.
Labrus burgall Bloch., Schn., p. 251.

This species is known to the fishermen as the 'conner.' It is abundant in Halifax Harbor during the summer months, and is readily taken with hook and line by boys at the wharves. In the summer of 1862, when the French fleet anchored here, the sailors used to catch them in great numbers for cooking, but the inhabitants rarely touch them. At St. Margaret's Bay, according to Mr. Ambrose, they are given as food to pigs; but as the pork of these fish-fed pigs always tastes oily in consequence, they are generally fed upon other food, and well dosed with sulphur, for a short time prior to being killed.

Gunther gives as a variety of this species *C. uninotatus*, which is taken in our harbor in company with the former. It differs in having a black spot on the base of the two anterior soft dorsal rays. DeKay makes it a distinct species.

PIPE-FISH.—*Fistularia* — ?

A very fine specimen of this genus was taken on the 16th of September 1863, at Portuguese Cove, near Halifax. As I had only an opportunity of examining it for a few minutes after its purchase by a tradesman, the following very deficient description was all I could draw up at the time. It did not resemble very closely the *F. verrata* of Storer and DeKay, nor could I identify it with the *F. tabacaria* of the latter author, although the orbital processes corresponded. It was of greater size than either of the specimens mentioned by DeKay and Storer, and may possibly prove new to the Nova-Scotian fauna.

DESCRIPTION.—Extent from frontal extreme to caudal termination, 31 inches; from frontal extreme to base of snout immediately

anterior to eye cup, 7 inches; from frontal extreme to commencement of dorsal, 24 inches 2 lines; from frontal extreme to posterior edge of opercle, 10 inches; from pectorals to ventrals, 4 inches 7 lines; from ventrals to anal, 8 inches 8 lines; from anal to caudal, 4 inches 1 line; breadth at fifteen inches from frontal extreme, 1 inch $7\frac{1}{2}$ lines; over pectorals, 1 inch; over dorsal, 1 inch 2 lines; over caudal base, 4 lines; vertical base of caudal extreme, $3\frac{1}{2}$ lines; width of mouth over base of snout, 5 lines.

Head:—Width over eyes, 8 lines; vertical depth over eyes, 9 lines. Two bony processes at anterior occipital angle of eye cup.

Mouth:—Vertical gape, 1 inch; horizontal gape, $7\frac{1}{2}$ lines; armed with small teeth on vomer and jaws; lower jaw 2 lines in advance of upper.

Eyes:—Lateral diameter, 10 lines; vertical diameter, 5 lines.

Fins:—Pectoral; diameter at base, $7\frac{1}{2}$ lines. Dorsal; diameter at base, 1 inch $2\frac{1}{2}$ lines. Ventrals; extent, 9 lines; diameter at base, 3 lines. Anal; diameter at base, 1 inch $2\frac{1}{2}$ lines. Caudal; extent, 1 inch $7\frac{1}{2}$ lines; caudal filament broken off 1 inch $7\frac{1}{2}$ lines from base.

Color:—Above, reddish brown; beneath, cupreous, longitudinally lined with white.—*Communicated by the Natural History Society of [St. John] New Brunswick.*

OBITUARY NOTICES.

CAPT. JAMES M. GILLISS, U. S. N.—Captain Gilliss, the Superintendent of the Washington Observatory, died suddenly, at Washington, of apoplexy, on Thursday, the 9th of February. The Naval Observatory, under his charge at the time of his death, was constructed from his plans, and equipped with its original instruments by him, during the years 1843–44, Congress having authorized its establishment by an Act passed in 1842; but only since 1861, when Maury, faithless to his country, left his post of duty, has it been under his abler direction. It would have been better for the scientific reputation of the country had it continued in his hands. An earlier observatory at Washington fitted up mainly by him, had been the scene of his labors from 1838 to 1842, and in the volume containing the results—the *first* volume of American Astronomical Observations—Mr. Gilliss expresses in his Preface, his pleasure that “the prosecution of these observations should

have resulted in the foundation of a permanent Naval Observatory."

During the three years 1849 to 1851, Capt. Gilliss was in Chile in charge of the U. S. Expedition for determining the Solar Parallax; and if his observations failed of all that was expected of them, it was from the want of that coöperation in the northern hemisphere which was reasonably looked for by him. The National Intelligencer (Washington, U. S.) of the day before his death (Feb. 8), contains his last astronomical communication,—one relating to the planet Mars,—dated Feb. 7.

Capt. Gilliss was an observer of great skill and accuracy, a man of noble personal character, and a patriot in the highest sense of the word. Three of his sons have been in the recent armies of his country, and the eldest—a captain—reached home from the Libby prison, after four months' imprisonment, only the day before his father died.—*Silliman's Journal*.

GEORGE P. BOND.—It is seldom that astronomical science has received a more severe blow than that occasioned by the death of George Philips Bond, of Harvard College, Philips Professor of Astronomy, and Director of the Observatory connected with that institution. After a lingering illness of more than a year, during which his ardor in the study of the heavens led him oftentimes to exposures entirely incompatible with the state of his health, he closed a useful and an unblemished life on the 17th of February,—eight days after his compeer, Captain Gilliss.

As an accurate and truthful observer of astronomical phenomena, he was, without question, unequalled by any one in this country, and among the first in the world. In his short career he contributed many valuable papers of original discoveries and calculations to various periodicals and institutions in this and other countries. His greatest work, and that which gave him honor the world over, is his account of the Donati comet, which constitutes the third volume of the Annals of the Observatory. To this, the palm of unrivalled excellence has been freely awarded by the best astronomical observers of Europe.* Well trained by his lamented and dis-

* We are informed that, a month since, Mr. Bond received word from President De La Rue, of the Royal Astronomical Society, that the Society, at its last annual meeting in January, had voted him a gold medal for his work on this comet.

tinguished father, and taking advantage of the best telescope mounted in so high a southern latitude, he explored with searching scrutiny the great nebula of Orion, a work which he pursued with untiring zeal and anxiety in his latter days; and while we fear his waning strength may have left it incomplete in form, we are assured, and rejoice in the assurance, that abundant ability remains in the observatory to prepare it for publication.

We might dwell much longer on his astronomical history, but the necessary brevity of this notice requires that we should turn to his private life. It is rare indeed, that so many virtues are blended in any man. His innocent unpretending manners, the perfect absence of every air of vanity or pretension, crowned with an unwavering Christian faith and deep sense of religious obligation, secured for him, not the mere respect, but the kindest regard of all who had the happiness of his acquaintance.—*Silliman's Journal*.

BIOGRAPHICAL NOTICE OF THE LATE HUGH FALCONER, M.D., &c. &c.—Hugh Falconer was one of those rare men,—an original discoverer; and his life is deserving of a larger record than that of a man who gains the popular fame of a discoverer by writing of other men's labors.

On the 29th of February 1808, Hugh Falconer was born at Forres, in the north of Scotland, a town best known from its traditional connection with the 'blasted heath' of Macbeth. He received his early education at the grammar school of Forres, and afterwards studied arts for four years at the University of King's College, Aberdeen, and medicine for four years at the University of Edinburgh. From the former University he received the degree of A.M., and from the latter, in 1829, the degree of M.D. As a boy, he had exhibited a decided taste for the study of natural objects, which he eagerly followed up in Edinburgh under the systematic tuition of Profs. Graham and Jameson. Qualified for the practice of medicine by the diplomas of the Royal College of Surgeons and of the University of Edinburgh, he was nominated to an appointment as assistant-surgeon on the Bengal Establishment. But not having attained the required age of twenty-two years, and the real bent of his mind being upon natural history, he devoted the compulsory interval to assisting the late Dr. Nathaniel Wallich, in the distribution of his great Indian herbarium, and to the study of geology and palæontology. The Museum of the Geological Society, under the charge

of Mr. Lonsdale, gave him access to the collection of Indian fossil mammalia from the banks of the Irawaddy formed by Mr. John Crawford, during his mission to Ava. The description of these remains by Mr. Clift had excited much interest in the scientific world, as the first instance in which the ground was broken in the Palæontology of tropical regions. In both cases the occupation proved of material service to the subject of our memoir in his subsequent career, and in the latter instance it determined the labors to which he afterwards so zealously devoted himself. For, immediately after his arrival in Calcutta, in September 1830, he undertook the examination of a collection of fossil bones from Ava, in the possession of the Asiatic Society of Bengal, and communicated a short paper upon them, which appeared early in 1831, in the third volume of the 'Gleanings in Science,' an Indian journal then conducted by the late Mr. James Prinsep.

Early in 1831, Dr. Falconer was ordered to the army station of Meerut, in the north-western provinces. His first and last military duty during twenty-six years of service was to take charge of a detachment of invalids proceeding to the Sanatorium of Landour in the Himalayas. This led him to pass through Suharunpore, where the late Dr. Royle was then superintendent of the Botanic Gardens. Kindred tastes and common pursuits soon knit Falconer and Royle together; and at the instance of his friend, Falconer was speedily appointed to officiate for him during leave of absence, and, on his departure for Europe in 1832, to succeed him in charge of the Botanic Garden.

In 1832 Dr. Falconer commenced his field explorations by an excursion to the sub-Himalayan range; and from the indication of a specimen in the collection of his friend and colleague Captain, now Sir Proby T. Cautley, he was led to discover vertebrate fossil remains *in situ* in the tertiary strata of the Sewalik Hills. Early in 1834 Dr. Falconer gave a brief account of the Sewalik Hills, describing their physical features and geological structure, with the first published section showing their relation to the Himalayas.

The researches thus begun were followed, about the end of 1834, by the discovery, by Lieuts. Baker and Durand, of the great ossiferous deposits of the Sewaliks, near the valley of Markunda, westward of the Jumna and below Nahun. Capt. Cautley and Dr. Falconer were immediately in the field; and, by the joint labors of these four officers, a sub-tropical mammalian fossil Fauna was brought to light, unexampled for richness and

extent in any other region then known. The Sewalik explorations soon attracted notice in Europe, and in 1837 the Wollaston medal in duplicate was awarded for their discoveries to Dr. Falconer and Capt. Cautley, by the Geological Society, the fountain of geological honors in England.

Concurrently with these researches, Dr. Falconer's official duties as superintendent of the Suharunpore Botanic Garden led him to explorations in the snowy range of the neighboring Himalayas. In 1834, a commission was appointed by the Bengal government to inquire into and report on the fitness of India for the growth of the tea plant of China. Acting on the information and advice supplied by Dr. Falconer, the commission recommended a trial. The government adopted the recommendation; the plants were imported from China, and the experimental nurseries were placed under Falconer's superintendence in sites selected by him. Tea-culture has since been greatly extended in the north-west.

In 1837 Dr. Falconer was ordered to accompany Burnes's second mission to Caubul, which preceded the Affghan war. United at Peshawur, the party consisted of Burnes, Mackeson, Leech, Lord, Wood, and Falconer. Of these six officers, the sole survivor now is Wood, the explorer of the Oxus. Dr. Falconer first proceeded westward to Kohat, and the lower part of the valley of Bunguish, in order to examine the Trans-Indus portion of the Salt range; and then, in company with Lieut. Mackeson, made for Cashmeer, where he passed the winter and spring, examining the natural history of the valley. The following summer (1838) he crossed the mountains to Iskardo, in Bulkistan, and, by the aid of Rajah Ahmed Shah, traced the Shiggar branch of the Indus to its source in the glacier on the southern flank of the Mooztagh range, now ascertained to be 28,200 feet above the level of the sea. Having examined the great glaciers of Arindoh and of the Brahdoh valley, he then returned to India, *via* Cashmeer and the Punjab, towards the close of 1838, to resume charge of his duties at Suharunpore. During the whole of this expedition to Cashmeer, Falconer kept copious diaries, which, it is to be hoped, are in a state fit for publication.

In 1840, his health, shattered by previous attacks of jungle fever, rheumatic fever, dysentery, and disease of the liver, the results of incessant exposure, gave way; alarming indications of constitutional break up set in; and in 1842 he was compelled to seek for a chance of recovery by sick leave to Europe, bringing

the natural history collections amassed by him during years of exploration of the Himalayas and plains of India.

Soon after his arrival in England in the autumn of 1843, fresh duties devolved on him in connection with the Sewalik fossils. Capt. Cautley had presented his vast collection to the British Museum. Its extent and value may be estimated from the fact that it filled 214 large chests, and that the charges on its transmission alone to England amounted to £602 stg. Dr. Falconer's selected collection was divided between the India House and the British Museum: the great mass was presented to the former, but a large number of unique or choice specimens, required to fill blanks or improve series, was presented to the latter. Most of the specimens were still imbedded in matrix. The authorities at the India House fitted up a museum room specially for the reception of their acquisitions; and Sir Robert Peel's government gave a liberal grant to prepare the materials in the national museum for exhibition in the Palæontological gallery. Dr. Falconer was intrusted with the superintendence of the work, and rooms were temporarily assigned to him by the Trustees in the British Museum.

His botanical collections were less fortunate. Having partially suffered from damp on the voyage to England, they were left deposited in the India House during his second absence in India, and the specimens underwent a ruinous process of decay. In 1857 Dr. J. D. Hooker applied to the Court of Directors for the herbarium collections in the India House, and saved a few of the Cashmeer and Himalayan dried plants.

In 1848, on the retirement of the late Dr. Wallich, Dr. Falconer was appointed his successor as Superintendent of the Calcutta Botanic Garden, and Professor of Botany in the Medical College. In 1850 he was deputed to the Tenasserim Provinces to examine the teak forests, which were threatened with exhaustion from reckless felling and neglected conservation. His Report, suggesting remedial measures, was published in 1850, in the "Selections from the Records of the Bengal Government." In 1852 he communicated a paper "On the Quinine-yielding Cinchonas and their Introduction into India." In 1854, assisted by his friend, the late Mr. Henry Walker, he undertook a "Descriptive Catalogue of the Fossil Collections in the Museum of the Asiatic Society of Bengal," which was published as a distinct work in 1859. In the spring of 1855 he retired from the Indian Service;

and on his return home he visited the Holy Land, whence he proceeded along the Syrian coast to Smyrna, Constantinople, and the Crimea, during the siege of Sebastopol.

Soon after his arrival in England he resumed his palæontological researches, and in 1857 he communicated to the Geological Society two memoirs "On the Species of Mastodon and Elephant occurring in the Fossil State in England." Having occupied himself during several years with the special investigation of the mammalian Fauna of the pliocene, as distinguished from that of the quaternary period of Europe, he was conducted to the examination of the Cave Fauna of England. In 1860 he communicated a memoir on the numerous ossiferous caves of Gower, explored or discovered by his friend, Lieut.-Col. Wood. The existence of *Elephas antiquus* and *Rhinoceros hamitæchus* as members of the Cave Fauna was then for the first time established, and the age of that Fauna precisely defined as posterior to the Boulder Clay, or period of the glacial submergence of England. In 1862; Dr. Falconer communicated to the British Association at Cambridge an account of *Elephas Melitensis*, the pigmy fossil elephant of Malta, discovered with other extinct mammals, by his friend, Capt. Spratt, C.B., in the ossiferous cave of Zebbug. This unexpected form presented the Proboscidea in a new light to naturalists.

For nearly thirty years Dr. Falconer had been engaged more or less with the investigation of a subject which has lately occupied much of the attention both of men of science and the educated classes generally, viz. the proof of the remote antiquity of the human race. In 1833, fossil bones, procured from a great depth in the ancient alluvium of the valley of the Ganges, in Hindostan, were figured and erroneously published as human. The subject attracted considerable attention at the time in India. In 1835, while this interest was still fresh, Dr. Falconer and Capt. Cautley discovered the remains of the gigantic miocene fossil tortoise of India, which, by its colossal size, realized the mythological conception of the tortoise which sustained the world on his back. About the same time, several species of fossil *Quadrumanus* were discovered in the Sewalik Hills, one of which was thought to have exceeded in size the ourang-outang, while another was hardly distinguishable by millimetrical differences from the living 'Hoonuman' monkey of the Hindoos. Coupling these facts with the occurrence of certain existing species, and of the camel, giraffe,

horse, &c., in the Sewalik Fauna, and with the further important fact that the plains of the valley of the Ganges had undergone no late submergence, and passed through no stage of glacial refrigeration to interrupt the previous tranquil order of physical conditions, Dr. Falconer and Capt. Cautley were so impressed with the conviction that the human race might have been early inhabitants of India, that they were constantly on the look out for the upturning of the relics of man or of his works from the miocene strata of the Sewalik Hills. In their account of the gigantic tortoise, after discussing the palæontological and mythological bearings of the case, they sum up by stating,—“The result at which we have arrived is, that there are fair grounds for entertaining the belief that the *Colossochelys Atlas* may have lived down to an early epoch of the human period, and become extinct since.”

Ten years later, Dr. Falconer resumed the subject in India, while investigating the fossil remains of the Jumna. In May, 1858, having the same inquiry in view, while occupied with his cave researches, he communicated a letter to the Council of the Geological Society, which suggested and led to the exploration of the Brixham cave, and the discovery in it of flint-implements of great antiquity, associated with the bones of extinct animals. In conjunction with Prof. Ramsay and Mr. Pengelly, he drew up a report on the subject, which, communicated in the autumn of the same year to the Councils of the Royal and Geological Societies, excited the interest of men of science in the case. Following up the same object, he immediately afterwards proceeded to Sicily, to examine the ossiferous caves there, and discovered the ‘Grotto di Maccagnone,’ in which flint implements of great antiquity were found adhering to the roof-matrix, mingled with remains of hyænas now extinct in Europe. Having examined the collection of M. Boucher de Perthes, on his route to Sicily, he was impressed with the authenticity of some of the flint implements discovered in the valley of the Somme, and urged his friend, Mr. Prestwich, who is of the highest authority in this branch of geology, to proceed there, and investigate the conditions of the case. Thus, in 1859, the subject of the antiquity of the human race, which had previously been generally discredited among men of science, was again launched upon fresh evidence in both the stratigraphical and cave aspects. Since then it has been actively followed up by numerous inquirers; and Dr. Falconer himself was contemplating, and had indeed actually commenced, a work on ‘Primeval Man.’

In 1863, Dr. Falconer took an active share in the singularly-perplexed discussion of the *cause célèbre* of the human jaw of Moulin-Quignon; and, in the conference of English and French men of science held in France, he expressed doubts as to its authenticity, but in that guarded and cautious manner which was characteristic of him. In the spring of last year he called attention in the 'Times' to an account of the remarkable works of art by 'Primeval Man' discovered by his friends, Messrs. Lartet and Henry Christy, in the ossiferous caves of the Dordogne; and in September he accompanied his friend, Prof. Busk, to Gibraltar, to examine caves in which marvellously well-preserved remains of man and mammals of great antiquity had been discovered. Before starting, he drew up, in conjunction with Mr. Busk, a preliminary report on the specimens brought from Gibraltar to this country, which was presented to the British Association at Bath. He suffered considerably from exposure and fatigue on his return journey through Spain from Gibraltar, so that the inclement winter told with additional force upon a constitution naturally susceptible of cold and weakened by long exposure and disease in India. On January 19th, on his return from a meeting of the Council of the Royal Society, he felt depressed and feverish. The attack speedily became developed into acute rheumatism, complicated with bronchitis and congestion of the lungs, which proved fatal on the morning of January 31st. On the 4th of February his remains were committed to their last resting-place, at Kensal Green, in the presence of a large number of his sorrowing friends and fellow-laborers.

From what has been said, it is obvious that Falconer did enough during his lifetime to render his name immortal in science as one of the greatest palæontologists that ever lived. But the work which he published was but a small fraction of that which he actually accomplished. The amount of scientific knowledge which has perished with him is prodigious, for he was cautious to a fault; he never liked to commit himself to an opinion until he was sure that he was right; and he has died, in the fulness of his power, before his race was run.—*Abridged from The Athenæum.*

REVIEWS.

"MONOGRAM OF THE BATS OF NORTH AMERICA." By H. Allen, M.D. Washington: Published by the Smithsonian Institute.

This is a valuable contribution to our knowledge of a group of animals little studied, though of great interest. As an incitement to their study, we take the following extracts from the introduction:—

Among the numerous agents which Nature employs for restricting the excessive increase of the insect world, the bats hold a conspicuous position. Eminently adapted to an animal regimen, the vast majority of these animals are exclusively insectivorous in their habits. Mosquitos, gnats, moths, and even the heavily-mailed nocturnal *Coleoptera*, fall victims in large numbers to their voracious appetites. Certain members of the order, such as flying Foxes (PTEROPODIDÆ), are strictly frugivorous, it is true; and others, as the Dog-bat of Surinam (*Noctula leporina*), classified as an insect-eating bat, partakes occasionally of fruit in addition to its more animal diet. None of the species found in this country, however, are known to subsist on any other than insect food. In this respect they hold a decided relationship to certain birds; and it is interesting to observe how, under different circumstances, these widely-separated animals serve us to the same end. The functions which the latter perform during the day, the former assume in the evening. The latter prey upon the diurnal insects, while the former feed exclusively upon the crepuscular and nocturnal kinds. The disappearance of the birds of day is a signal for the advent of the dusky host, which, as it were, temporarily relieve from duty their most brilliant rivals in guarding the interests of Nature.

But, while thus connected with birds in their position in the world's economy, bats have none of that grace of form or beauty of coloring so characteristic of the others. Their bodies are clumsy and repulsive; their hues are dull and unattractive; nor can the eye dwell with pleasure upon their grotesque and awkward motions. This aversion—so universally evinced toward these little animals—is heightened by the associations of the time and place of their daily appearance. Attendant, as they are, upon the quiet hours of twilight, when the thickening gloom is conducive to the development of superstitious feeling, bats have always been associated

with ideas of the horrible and the unknown. In olden times, when the imagination of the people exceeded the accuracy of their observations, it was one of the numerous monsters inhabiting their caverns and forests. It has done service in many a legend; its bite was fatal; it was the emblem of haunted houses; its wings bore up the dragon slain by St. George.

It is easy to trace from this early impression the permanent position that the bat, as an emblem of the repulsive, held in letters and the arts. It is mentioned in the book of Leviticus as one of the unclean things. Its image is rudely carved upon the tombs of the ancient Egyptians. The Greeks consecrated it to Proserpine. It is part of the infernal potion of the witches in Macbeth, while Ariel employs it in his erratic flights. In art, its wings have entered largely into the creation of those composite horrors, evil spirits; nor have modern artists escaped from the absurdity of encumbering the Satan of Holy Writ with like appendages.*

Of this association with the monstrous the intelligent observer ceases to take note when the finer beauties of structure develop themselves under his gaze. Upon acquaintance, he learns, perhaps with surprise, that, in anatomical and physiological peculiarities, and zoological position, the bat is a subject for study worthy of the attention of the most contemplative. Indeed no order of animals is more interesting, and none has received greater attention from the hands of savans.

The early pioneers of natural history were far astray in their endeavors to correctly define the nature and position of the bat.

"Some authors place bats among the birds, because they are able to fly through the air; while others assign them a position among the quadrupeds, because they can walk on the earth. Some again, who admitted the mammalian nature of the creatures, scattered them at intervals through the scale of animated beings, heedless of any distinction excepting the single characteristic in which they took their stand, and by which they judged every animal.

* To this fancy of the ancients of placing the wings of a bat upon demons, is happily opposed the sweet conceits of poets in adorning the figures of angels and cherubim with the wings of birds. The wing of a bat is sombre and angular; that of a bird is of delicate hues, and replete with curves. It is therefore poetic justice to have the one become an emblem of the infernal, as the other is an expression of the heavenly form.

These are but a few of the diverse opinions which prevailed among the naturalists of former times, among which the most ingeniously quaint is that which places the bat and the ostrich in the same order, because the bat has wings, and the ostrich has not."*

Without reviewing the recorded errors of these observers, we will be content to call the attention of the reader to the following brief account of the structure of flying animals, so that the true position of the bat among them may be definitely fixed.

There are two distinct types of modifications which the vertebrate skeleton has undergone in adapting the animal for flight, both of which depend upon some peculiarity in the structure of the anterior extremities ; and in order to obtain a correct opinion of them, we propose to cast a glance at each in turn.

The first act of the bat, after emerging in the evening from its retreat, is to fly to the water. The following account, illustrating the peculiarity, as well as showing the enormous numbers in which these animals will live together, is of great interest. It is from the pen of M. Figanieri, Minister to this country from Portugal, in a letter addressed to Prof. Henry, Secretary of the Smithsonian Institution :—

" In the winter of 1859, having purchased the property known as Seneca Point, on the margin of the Northeast River, near Charlestown, in Cecil County, Maryland, we took possession of it in May of the next year. The dwelling is a brick structure covered with slate in the form of an L two-storeyed, with garret, cellars, and a stone laundry and milk-house attached. Having been uninhabited for several years, it exhibited the appearance, with the exception of one or two rooms, of desolation and neglect, with damp, black walls, all quite unexpected, as it had been but very slightly examined, and was represented in good habitable condition, merely requiring some few repairs and a little painting.

" The boxes, bundles, and other packages of furniture which had preceded us, lay scattered around and within the dwelling : these, with the exception of some mattresses and bedding for immediate use, were hastily arranged for unpacking and placing in order at leisure. The weather, which was beautiful, balmy, and warm, invited us toward evening to out-door enjoyment and rest after a fatiguing day of travel and active labor ; but chairs, settees, and benches were scarcely occupied by us on the piazza and lawn,

*Wood, Nat. His., 1 (Mam.), 114.

when, to our amazement, and to the horror of the female portion of our party, small black bats made their appearance in immense numbers, flickering around the premises, rushing in and out of doors and through open windows—almost obscuring the early twilight, and causing a general stampede of the ladies, who fled, covering their heads with their hands, fearing that the dreaded little vampires might make a lodgment in their hair.

“ This remarkable exhibition much increased our disappointment in regard to the habitable condition of our acquisition, and was entirely unexpected, inasmuch as the unwelcome neighbors were in their dormant state and ensconced out of sight when the property was examined previous to purchase. With their appearance, and in such immense numbers, the prospect of immediate indoors arrangement and comfort vanished; the paramount, the urgent necessity was to get rid of such a nuisance as quickly as possible; and the question was, by what means could this be accomplished. Our scientific friends and acquaintances, both in New York and Philadelphia, were consulted; various volumes of natural history were examined in order to ascertain the peculiar habits of the vermin, but we derived no effectual consolation from these sources. One of our friends, indeed, sent us from New York an infallible exterminator in a form of a receipt obtained at no inconsiderable cost. Strips of fat pork saturated with a subtle poison were to be hung up in places where the annoying creatures did most congregate; of this they would surely eat, and thus ‘shuffle off their mortal coil.’ How many revolving bat-seasons it might have required by this process to kill off the multitude, the urgency of the case would not allow us to calculate, and the experiment was therefore abandoned.

“ Evening after evening did we patiently, though not complacently, watch this periodical exodus of dusky wings into light from their lurking-places one after another, and in some instances in couples and even triples, according as the size of the holes or apertures from which they emerged in the slate-roofing would permit. Their excursions invariably commenced with the cry of the ‘whip-poorwill,’ both at coming evening and early dawn; and it was observed that they always first directed their flight towards the river, undoubtedly to damp their mouse-like snouts, but not their spirits, for it was likewise observed that they returned to play hide and seek, and indulge in all other imaginable gambols; when, after gratifying their love of sport and satisfying their voracious appetites (as the absence of mosquitos and gnats testified), they would

re-enter their habitation, again to emerge at the first signal of their feathered trumpeter. I thus ascertained one very important fact, namely, that the bat, or the species which annoyed us, ate and drank twice in twenty-four hours. Such appeared their habit, such therefore was their indispensable need. Upon ascertaining this fact, after having tried suffocation by the fumes of brimstone with only partial success, I concluded to adopt a more efficient plan of warfare ; and for this purpose commenced by causing all the holes, fissures in the wood-work, and apertures in the slating to be hermetically sealed with cement. This put a stop to their egress. But to avoid their dying by starvation and deprivation of water, which would manifold increase the annoyance by adding their dead to their living stench, I ordered apertures of about two feet square to be opened in the lathe and plastered partition on each side of the garret windows, and also in the ceiling of every garret room ; lastly, when the bats' reveille was sounded by the bugle of the whippoorwill, all the hands of our establishment, men and boys, each armed with a wooden implement (shaped like a cricket-bat), marched to the third floor, 'on murderous deeds with thoughts intent;' a lighted lantern was placed in the middle of one room, divested of all furniture, to allure the hidden foe from their strongholds. After closing the window, to prevent all escape into the open air, the assailants, distributed at regular distances to avoid clubbing each other, awaited the appearance of the bats, enticed into the room by the artificial light, and impelled by their own natural craving. The slaughter commenced, and progressed with sanguinary vigor for several hours, or until brought to a close by the weariness of dealing the blows that made the enemy bite the dust, and overpowered by the heat and closeness of the apartment. This plan succeeded perfectly. After a few evenings of similar exercise, in which the *batteurs* became quite expert in the use of their weapon, every wielding of the wooden bat bringing down an expiring namesake, the war terminated by the extermination of every individual of the enemy in the main building. However, there still was the cock-loft of the laundry, which gave evidence of a large population. In this case I had recourse to a plan which had been recommended, but was not carried out in regard to the dwelling-house. I employed a slater to remove a portion of the slating which required repairing. This process discovered some fifteen hundred or two thousand bats, of which the larger number were killed, and the remainder sought the barn, trees, and other places of concealment in the neighborhood.

"In the main building nine thousand six hundred and forty bats, from actual counting, were destroyed. This was ascertained in the following manner: After the battling of each evening the dead were swept in one corner of the room, and in the morning, before removing them to the manure-heap, they were carefully counted and recorded. Many had been killed before and some few after the reckoning was made, and were not included in it, nor were those killed under the adjoining laundry roof. The massacre commenced by killing fewer the first evenings, the number increasing, and then diminishing towards the end; but it was generally from fifty or a hundred, up to six hundred and fifty,—the highest mortality of any evening's work,—dwindling down to eight, five, three, and two.

"This species of bat is generally small, black, and very lively. Some smaller than the ordinary size were found, probably young ones, and one or two larger, supposed to be grandfathers, or of a reddish hue, which was thought to be from age. These vermin were generally more or less covered with a small-sized bug, not very dissimilar to the common chinch, but of a different species. As previously stated, the bat has a very disagreeable odor, which pertains to its ejection.

"The manure, as well as the bodies of the slain, was used to fertilize the flower and vegetable garden; and thus, in some degree, they served to compensate us for the annoyance to which we had been subjected. The manure, however, required to be applied with caution; since, if used in too large a quantity, it appeared to burn the organism of the plants.

"To remove the very disagreeable odor which remained in the upper part of the house, various kinds of disinfectants were employed with some advantage; but the most effectual method resorted to was that of opening holes of about four inches square, two at each gable-end, to permit a current of air to pass through.

"These holes were covered with iron gauze to prevent the re-entrance of any of the remainder of the army of the enemy which might hover around the premises.

"At the end of five years the odor has now nearly disappeared, being hardly perceptible during a continuance of very damp weather."

The fact mentioned above of the numerous parasites infesting bats is perhaps the most revolting features in these creatures. The enormous population of *Acari* found upon their bodies is due to the great generation of animal heat in their close haunts, a

condition conducive to a rapid increase of all kinds of vermin. In this country the common bed-bug (*Cimex lectularis*) is frequently found upon their fur. The entrance of a bat with its precious burden, into the open window of a farm-house, is the solution of that frequently-propounded question of the despairing house-wife, "Where *can* the bugs come from?"

Of individual anecdotes of bats we have but few examples. The following, illustrating the material instinct, is taken from Godman's Nat. Hist., i, 1831, 56. It is narrated by Mr. Titian Peale:—

"In June, 1823, the son of Mr. Gillespie, the keeper of the city square, caught a young red bat (*L. Nov-Eboracensis*), which he took home with him. Three hours afterwards, in the evening, as he was conveying it to the Museum in his hand, while passing near the place where it was caught, the mother made her appearance and followed the boy for two squares, flying around him, and finally alighted on his breast, such was her anxiety to save her offspring. Both were brought to the Museum—the young one firmly adhering to its mother's teat. This faithful creature lived two days in the Museum, and then died of injuries received from her captor. The young one, being but half grown, was still too young to take care of itself, and died shortly after."

Like most specialists in these days, the author has a tendency to form genera and families on very trivial characters, and thus arrives at a classification which, though convenient for reference, is not natural. As a consequence of this, he elevates the bats to the rank of an *Order*, an arrangement which certainly will not accord with any natural division of the class Mammalia.

Of the species described in the work, the following have been recognised at Montreal:

Lasiurus cinereus, Palisot de Beau-	Scotophilus noctivagans, Leconte,
vois, (the Hoary Bat).	(the Silvery-haired Bat).
Lasiurus Nov-Eboracensis, Tomes,	Vespertilis subulatus, Say,
(the Red Bat).	(the Little Brown Bat).

"FLORA OF THE BRITISH WEST-INDIAN ISLANDS." By A. H. R. Grisebach, M.D., Professor of Botany, in the University of Gottingen, London, 1864.

This is one of the Colonial Floras, to which reference has often been made in our pages. It includes all the Phenogamic-

plants and vascular Cryptogamia, with full indices and a table of the local names. Dr. Gray says of it: "The preface gives an account of the circumstances under which the work was undertaken, and of the materials which the author so sedulously and promptly elaborated. West-Indian botany was very difficult and confused: 'Almost all the principal authors who have written on West-Indian plants belong to the last century, and consequently to the Linnæan school, and a general synopsis of West-Indian plants has never before been attempted, not even by Swartz, whose flora contains descriptions of his new species only, with a few remarks on allied forms.' Moreover, the British West Indies offer only the separate fragments of a larger flora. Trinidad, as its geographical situation indicates, naturally belongs to the flora of Venezuela and Guiana. The northern Bahamas might be supposed to have a vegetation very like that of East Florida, from which they are separated by the Gulf Stream; but this seems not to be the case. 'Jamaica, again, from its mountainous character and more distant position; most of the Leeward islands, from being wooded volcanos; and the majority of the windward ones, with a dry climate and a low calcareous soil,—form three divisions of this tropical archipelago, which show as many peculiarities. Thus the whole of the British West Indies, as comprised in this flora, may be divided into five natural sections, each with a distinct botanical character.' Altogether they amount to about 15,000 English square miles, or nearly twice the area of Wales. But yet Hayti alone is nearly twice, and Cuba nearly thrice, as large as all the British Islands together, and not only far richer in vegetation, but far less explored; the publications of Jacquin, Swartz, &c., having been almost confined to the British possessions; so that it was with old species mainly, that Dr. Grisebach had to deal, those which were 'the foundation, indeed, of our scientific knowledge of the flora of tropical America. And these have so often been misunderstood that their synonyms are far more numerous than their numbers.' A general West-Indian flora being out of the present question, we learn with interest that Dr. Grisebach is preparing a special paper on the geographical range of the West-Indian plants, including the capital island of Cuba, which Mr. Charles Wright has so industriously and successfully explored through its length and breadth, and is expecting still further to explore."

COUNT RUMFORD AND HIS RESEARCHES ON HEAT.—The highest law in physical science which our faculties permit us to perceive, is, to quote the words of Faraday, "the Conservation of Force." The generalizations which serve to illustrate this great principle of the conservation of force in all its varied applications, are generally referred to as the law of the Correlation of Forces, and have been set forth by various writers within the last twenty years. Prof. Youmans, who is already favorably known for his new Class-book of Chemistry,—a work which deserves, by its lucid method, scientific accuracy, and felicity of illustration, to supersede all others as an elementary manual,—has just rendered an important service to the scientific student by bringing together in a single volume a series of expositions of this doctrine of the correlation and conservation of force,* by Grove, Helmholtz, Mayer, Faraday, Liebig, and Carpenter. With the exception of the first named, a treatise of considerable extent, and of great merit, which has gone through at least two editions, and the wonderful essay of Mayer on Celestial Dynamics, the productions here collected are scattered through scientific journals not always accessible to the general reader. Besides bringing them together with notes, explanatory remarks, and a good index, Dr. Youmans has, in a modest introduction of forty pages, given a review of the subject, and has called attention to the labor of that most remarkable thinker of our day, Herbert Spencer, who, to use our author's words, "has the honor of crowning this sublime inquiry by showing that the law of conservation, or, as he prefers to call it, of the Persistence of Force, as it is the underlying principle of all being, is also the fundamental truth of all philosophy."

It would have added to the value of this excellent compilation if our author had included in it the essay of Dr. Joseph Henry, on the Conservation of Force, published in the Agricultural Report of the United States Patent Office for 1857, and in Silliman's Journal [2], xxx, 32; and Dr. Joseph Leconte's exposition of the Correlation of Physical, Chemical, and Vital Forces, and of the Conservation of Forces in Vital Phenomena, which appeared in the same Journal [2], xxviii, 305. A valuable, and in many respects,

* The Correlation and Conservation of Forces : a series of expositions by Prof. Grove, Prof. Helmholtz, Dr. Mayer, Dr. Faraday, Prof. Liebig, and Dr. Carpenter. With an introduction and brief biographical notices of the chief promoters of the new views : by Edward L. Youmans, M.D. New York : D. Appleton & Co. Montreal : Dawson Brothers.

original contribution to this subject will be found in a thesis by Dr. Maurice Bucke on the Correlation of Physical and Vital Forces, Montreal, 1862.

Our object at present, however, in noticing Dr. Youmans's book is to bring before our readers his sketch of the life and scientific labors of Count Rumford, to whom, as he has proved, belongs the merit of having, long before any other one, shown that heat was a mode of motion, demonstrating its immateriality and the conversion of its mechanical force into heat. It is, says Dr. Youmans, with a just feeling of national pride, that we recall that "the two men who first demonstrated the two capital propositions of pure science, that lightning is but a manifestation of electricity, and heat but a mode of motion, were not only Americans by birth and education, but men eminently representative of the peculiarities of American character—Benjamin Franklin and Benjamin Thompson, afterwards known as Count Rumford."

"Benjamin Thompson was born at Woburn, Mass., in 1753. He received the rudiments of a common school education; became a merchant's apprentice at twelve, and subsequently taught school. Having a strong taste for mechanical and chemical studies, he cultivated them assiduously during his leisure time. At seventeen he took charge of an academy in the village of Rumford (now Concord), N. H., and in 1772 married a wealthy widow, by whom he had one daughter. At the outbreak of revolutionary hostilities he applied for a commission in the American service, was charged with toryism, left the country in disgust, and went to England. His talents were there appreciated, and he took a responsible position under the government, which he held for some years.

"After receiving the honor of knighthood, he left England and entered the service of the elector of Bavaria. He settled in Munich in 1784, and was appointed aide-de-camp and chamberlain to the Prince. The labors which he now undertook were of the most extensive and laborious character, and could never have been accomplished but for the rigorous habits of order which he carried into all his pursuits. He reorganized the entire military establishment of Bavaria, introduced not only a simple code of tactics, and a new system of order, discipline, and economy among the troops, and industrial schools for the soldiers' children, but greatly improved the construction and modes of manufacture of arms and ordnance. He suppressed the system of beggary, which had grown into a recognized profession in Bavaria, and become an enormous

public evil;—one of the most remarkable social reforms on record. He also devoted himself to various ameliorations, such as improving the construction and arrangement of the dwellings of the working classes, providing for them a better education, organizing houses of industry, introducing superior breeds of horses and cattle, and promoting landscape-gardening, which he did by converting an old abandoned hunting-ground near Munich into a park, where, after his departure, the inhabitants erected a monument to his honor. For these services Sir Benjamin Thompson received many distinctions, and among others was made Count of the Holy Roman Empire. On receiving this dignity he chose a title in remembrance of the country of his nativity, and was thenceforth known as Count of Rumford.

“His health failing from excessive labor and what he considered the unfavorable climate, he came back to England in 1798, and had serious thoughts of returning to the United States. Having received from the American government the compliment of a formal invitation to revisit his native land, he wrote to an old friend requesting him to look out for a ‘little quiet retreat’ for himself and daughter in the vicinity of Boston. This intention, however, failed, as he shortly after became involved in the enterprise of founding the Royal Institution of England.

“There was in Rumford’s character a happy combination of philanthropic impulses, executive power in carrying out great projects, and versatility of talent in physical research. His scientific investigations were largely guided and determined by his philanthropic plans and public duties. His interest in the more needy classes led him to the assiduous study of the physical wants of mankind, and the best methods of relieving them; the laws and domestic management of heat accordingly engaged a large share of his attention. He determined the amount of heat arising from the combustion of different kinds of fuel, by means of a calorimeter of his own invention. He reconstructed the fire-place, and so improved the methods of heating apartments and cooking food as to produce a saving in the precious element, varying from one-half to seven-eighths of the fuel previously consumed. He improved the construction of stoves, cooking-ranges, coal-grates, and chimneys; showed that the non-conducting power of cloth is due to the air enclosed among its fibres, and first pointed out that mode of action of heat called *convection*; indeed he was the first clearly to discriminate between the three modes of propagation of

heat,—radiation, conduction, and convection. He determined the almost perfect non-conducting properties of liquids, investigated the production of light, and invented a mode of measuring it. He was the first to apply steam generally to the warming of fluids and to the culinary art; he experimented upon the use of gunpowder, the strength of materials, and the maximum density of water, and made many valuable and original observations upon an extensive range of subjects.

“Prof. James D. Forbes, in his able Dissertation on the recent Progress of the Mathematical and Physical Sciences, in the last edition of the *Encyclopedia Britannica*, gives a full account of Rumford’s contributions to science, and remarks :

‘All of Rumford’s experiments were made with admirable precision, and recorded with elaborate fidelity, and in the plainest language. Every thing with him was reduced to weight and measure, and no pains were spared to attain the best results.

‘Rumford’s name will be ever connected with the progress of science in England by two circumstances; first, by the foundation of a perpetual medal and prize in the gift of the council of the Royal Society of London, for the reward of discoveries connected with heat and light; and secondly, by the establishment in 1800 of the Royal Institution in London, destined primarily for the promotion of original discovery, and secondarily for the diffusion of a taste for science among the educated classes. The plan was conceived with the sagacity which characterized Rumford, and its success has been greater than could have been anticipated. Davy was there brought into notice by Rumford himself, and furnished with the means of prosecuting his admirable experiments. He and Mr. Faraday have given to that institution its just celebrity, with little intermission, for half a century.’

“Leaving England, Rumford took up his residence in France, and the estimation in which he was held may be judged of by the fact that he was elected one of the eight foreign associates of the Academy of Sciences.

“Count Rumford bequeathed to Harvard University the funds for endowing its professorship of the Application of Science to the Art of Living, and instituted a prize to be awarded by the American Academy of Sciences for the most important discoveries and improvements relating to heat and light. In 1804 he married the widow of the celebrated chemist Lavoisier, and with her retired to the villa of Auteuil, the residence of her former husband, where he died in 1814.

"Having thus glanced briefly at his career, I now pass to the discovery upon which Count Rumford's fame in the future will chiefly rest. It is described in a paper published in the transactions of the Royal Society for 1798.

"He was led to it while superintending the operations of the Munich arsenal, by observing the large amount of heat generated in boring brass cannon. Reflecting upon this, he proposed to himself the following questions: Whence comes the heat produced in the mechanical operations above mentioned? Is it furnished by the metallic chips which are separated from the metal?

"The common hypothesis affirmed that the heat produced had been latent in the metal, and had been forced out by *condensation* of the chips. But if this were the case, the capacity for heat of the parts of metal so reduced to chips ought not only to be changed, but the change undergone by them should be sufficiently great to account for *all* the heat produced. With a fine saw Rumford then cut away slices of the unheated metal, and found that they had *exactly the same capacity for heat as the metallic chips*. No change in this respect had occurred, and it was thus conclusively proved that the heat generated could not have been held latent in the chips. Having settled this preliminary point, Rumford proceeds to his principal experiments.

"With the intuition of the true investigator, he remarks that 'very interesting philosophical experiments may often be made, almost without trouble or expense, by means of machinery contrived for mere mechanical purposes of the arts and manufactures.' Accordingly, he mounted a metallic cylinder weighing 113.13 pounds avoirdupois, in a horizontal position. At one end there was a cavity three and a half inches in diameter, and into this was introduced a borer, a flat piece of hardened steel, four inches long, 0.63 inches thick, and nearly as wide as the cavity, the area of contact of the borer with the cylinder being two and a half inches. To measure the heat developed, a small round hole was bored in the cylinder near the bottom of the cavity, for the insertion of a small mercurial thermometer. The borer was pressed against the base of the cavity with a force of 10,000 pounds, and the cylinder made to revolve by horse-power at the rate of thirty-two times per minute. At the beginning of the experiment the temperature of the air, in the shade, and also in the cylinder was 60°F.; at the end of thirty minutes, and after the cylinder had made 960 revolutions, the temperature was found to be 130°F.

“ Having taken away the borer, he found that 839 grains of metallic dust had been cut away. ‘Is it possible,’ he exclaims, ‘that the very considerable quantity of heat produced in this experiment—a quantity which actually raised the temperature of upward of 113 pounds of gun-metal at least 70° —could have been furnished by so inconsiderable a quantity of metallic dust, and this merely in consequence of a change in the capacity for heat?’

“ To measure more precisely the heat produced, he next surrounded his cylinder by an oblong wooden box in such a manner that it could turn water-tight in the centre of the box, while the borer was pressed against the bottom. The box was filled with water until the entire cylinder was covered, and the apparatus was set in action. The temperature of the water on commencing was 60° . He remarks, ‘The result of this beautiful experiment was very striking, and the pleasure it afforded amply repaid me for all the trouble I had taken in contriving and arranging the complicated machinery used in making it. The cylinder had been in motion but a short time when I perceived, by putting my hand into the water and touching the outside of the cylinder, that heat was generated.’

“ As the work continued, the temperature gradually rose; at two hours and twenty minutes from the beginning of the operation, the water was at 200° , and in ten minutes more it actually boiled! Upon this result Rumford observes, ‘It would be difficult to describe the surprise and astonishment expressed in the countenances of the bystanders, on seeing so large a quantity of water heated and actually made to boil without any fire. Though there was nothing that could be considered very surprising in this matter, yet I acknowledge fairly that it afforded me a degree of childish pleasure which, were I ambitious of the reputation of a grave philosopher, I ought most certainly rather to hide than to discover.’

“ Rumford estimated the total heat generated as sufficient to raise 26.58 pounds of ice-cold water 180° , or to its boiling-point; and he adds, ‘from the results of these computations, it appears that the quantity of heat produced equally, or in a continuous stream, if I may use the expression, by the friction of the blunt steel borer against the bottom of the hollow metallic cylinder, was *greater* than that produced in the combustion of nine wax candles each three-quarters of an inch in diameter, all burning together with clear bright flames.

‘One horse would have been equal to the work performed, though two were actually employed. Heat may thus be produced merely by the strength of a horse, and in a case of necessity this might be used in cooking victuals. But no circumstances could be imagined in which this method of producing heat could be advantageous, for more heat might be obtained by using the fodder necessary for the support of the horse, as fuel.

‘By meditating on the results of all these experiments, we are naturally brought to that great question which has so often been the subject of speculation among philosophers, namely, What is heat? Is there such a thing as an igneous fluid? Is there anything that with propriety can be called caloric?

‘We have seen that a very considerable quantity of heat may be excited by the friction of two metallic surfaces, and given off in a constant stream or flux *in all directions*, without interruption or intermission, and without any signs of *diminution* or *exhaustion*. In reasoning on this subject we must not forget *that most remarkable circumstance*, that the source of the heat generated by friction in these experiments appeared evidently to be *inexhaustible*. [The italics are Rumford’s.] It is hardly necessary to add, that anything which any *insulated* body or system of bodies can continue to furnish *without limitation*, cannot possibly be a *material substance*; and it appears to me to be extremely difficult, if not quite impossible, to form any distinct idea of anything capable of being excited and communicated in those experiments, except it be MOTION.’

“No one can read the remarkably able and lucid paper from which these extracts are taken, without being struck with the perfect distinctness with which the problem to be solved was presented, and the systematic and conclusive method of its treatment. Rumford kept strictly within the limits of legitimate inquiry, which no man can define better than he did. ‘I am very far from pretending to know how, or by what means or mechanical contrivances, that particular kind of motion in bodies, which has been supposed to constitute heat, is exerted, continued, and propagated, and I shall not presume to trouble the Society with new conjectures. But although the mechanism of heat should in part be one of those mysteries of nature which are beyond the reach of human intelligence, this ought by no means to discourage us, or even lessen our ardor in our attempts to investigate the laws of its operations. How far can we advance in any of the paths which

science has opened to us, before we find ourselves enveloped in those thick mists, which on every side bound the horizon of the human intellect!

“Rumford’s experiments completely annihilated the material hypothesis of heat, while the modern doctrine was stated in explicit terms. He moreover advanced the question to its quantitative and highest stage, proposing to find the numerical relation between mechanical power and heat, and obtained a result remarkably near to that finally established. The English unit of force is the foot-pound, that is, one pound falling through one foot of space; the unit of heat is one pound of water heated 1°F . Just fifty years subsequently to the experiment of Rumford, Dr. J. P. Joule, of Manchester, England, after a most delicate and elaborate series of experiments, determined that 772 units of force produce one unit of heat; that is, 772 pounds falling through one foot produces sufficient heat to raise one pound of water 1°F . This law is known as the mechanical equivalent of heat. Now, when we throw Rumford’s results into these terms, we find that about 940 units of force produced a unit of heat, and that, therefore, on a large scale, and at the very first trial, he came within twenty per cent. of the true statement. No account was taken of the heat lost by radiation, which, considering the high temperature produced, and the duration of the experiment, must have been considerable; so that, as Rumford himself noticed, this value must be too high. The earliest numerical results in science are rarely more than rough approximations, yet they may guide to the establishment of great principles. Certainly no one could question Dalton’s claim to the discovery of the law of definite proportions, because of the inaccuracy of the numbers upon which he first rested it.

* * * * *

“Those doctrines [of the correlation and conservation of forces] have received their subsequent development in the various directions, by many minds, but we may be allowed to question if the contributions of any of their promoters will surpass, if indeed they will equal, the value and importance which we must assign to the first great experimental step in the new direction.

“The claims of Rumford may be summarized as follows:

- I. He was the man who first took the question of the nature of heat out of the domain of metaphysics, where it had

been speculated upon since the time of Aristotle, and placed it upon the true basis of physical experiment.

- II. He first proved the insufficiency of the current explanations of the sources of heat, and demonstrated the falsity of the prevailing view of its materiality.
- III. He first estimated the quantitative relation between the heat produced by friction and that by combustion.
- IV. He first showed the quantity of heat produced by a definite amount of mechanical work, and arrived at a result remarkably near the finally-established law.
- V. He pointed out other methods to be employed in determining the amount of heat produced by the expenditure of mechanical power, instancing particularly the agitation of water, or other liquids, as in churning.
- VI. He regarded the power of animals as due to their food, therefore as having a definite source and not created; and thus applied his views of force to the organic world.
- VII. Rumford was the first to demonstrate the quantitative convertibility of force in an important case; and the first to reach, experimentally, the fundamental conclusion that heat is but a mode of motion.

"In his late work upon heat, Prof. Tyndall, after quoting copiously from Rumford's paper, remarks: 'When the history of the dynamical theory of heat is written, the man who, in opposition to the scientific belief of his time, could experiment, and reason upon experiment, as did Rumford in the investigation here referred to, cannot be lightly passed over.' Had other English writers been equally just, there would have been less necessity for the foregoing exposition of Rumford's labors and claims; but there has been a manifest disposition in various quarters to obscure and depreciate them. Dr. Whewell, in his history of the Inductive Sciences, treats the subject of thermotics without mentioning him. An eminent Edinburgh professor, writing recently in the *Philosophical Magazine*, under the confessed influence of 'patriotism,' undertakes to make the dynamical theory of heat an English monopoly, due to Sir Isaac Newton, Sir Humphrey Davy, and Dr. J. P. Joule; while an able writer in a late number of the *North British Review*, in sketching the historic progress of the new views, puts Davy forward as their founder, and assigns to Rumford a minor and subsequent place."

THE CANADIAN NATURALIST.

SECOND SERIES.

CONTRIBUTIONS TO THE CHEMISTRY OF NATURAL WATERS.

By T. STERRY HUNT, A.M., F.R.S.; of the Geol. Survey of Canada.

II.

ANALYSES OF VARIOUS NATURAL WATERS.

CONTENTS OF SECTIONS.—35, mode of analysis, date of collection; 37, waters of the first class; 37, their probable origin; the elimination of sulphates; 38, separation of lime-salts from waters; 39, earthy chlorids in saliferous formations; brines of New York, Michigan, and England; foot-note on errors in water-analyses; 40, brines of western Pennsylvania; waters in which chlorid of calcium predominates; 41, origin of such waters; separation of magnesia as an insoluble silicate; 42, waters of the second class; 43, waters of the third class; 44, waters of the fourth class; Chambly; 45, other waters of the same class; Ottawa River; 46, waters of Highgate and Alburg; 47, changes in the Caledonia waters; comparative analyses; 48, waters of the fifth class; sulphuric-acid springs of New York and Canada; 49, changes in the composition of these waters; their action on calcareous strata; 50, waters of the sixth class, their various sources; 51, examples of neutral sulphated waters; sulphate of magnesia waters.

§ 35. The analyses of the various mineral waters to be given in the second part of the present paper, were made according to the modes laid down in the treatise of Fresenius on Quantitative Analysis. The carbonate of soda in the alkaline waters was determined by the excess of the alkaline bases over the chlorine and sulphuric acid present. This was generally controlled by the amount of the carbonate of baryta thrown down from a solution of chlorid of barium by a solution of the soluble salts obtained by the evaporation of the mineral water; and in some cases, to be specified farther on, this latter process was relied on as the only means

of determining the amount of carbonate of soda. For some remarks on the earthy carbonates of the waters, and on their relation to the results of analysis, see part III of this paper.

The date at which the various waters were collected for analysis is in each case appended to the notice of the spring. This is of the greater importance, inasmuch as it will be shown that in the course of years, some of those springs here described have suffered considerable changes in their composition.

§ 36. In the following table are given the analyses of several waters belonging to the first class, as defined in § 34.*

1.—This water is from a well thirty feet in depth, near the village of Ancaster, on the western shore of Lake Ontario. It is sunk in the Niagara formation; but like the other waters of this class, probably has its source in the Lower Silurian limestones. The water rises nearly to the surface, but there is no perceptible discharge. Its temperature was found to be 48° F. when collected for analysis in September 1847.

2. This water is from a copious spring which issues from the limestones of the Trenton group at Whitby, on the north shore of Lake Ontario. It contained small portions of baryta and strontia, and was collected in October 1853.

3, 4. Several wells have been sunk in the Trenton limestone in the township of Hallowell, on the Bay of Quinté, Lake Ontario, in search of brine for salt-making, and have yielded bitter saline waters, of which the two here noticed are examples. No. 3 was obtained from a well twenty-seven feet deep, in October 1853. No. 4 was taken in the summer of 1854 from a well a mile or two distant from the last. Neither of these waters was examined for baryta or strontia.

5, 6. At St. Catharines, near Niagara Falls, a boring of five inches in diameter was carried to a depth of about 500 feet, and after traversing the Medina formation, is said to have penetrated fifty or sixty feet into the Hudson River shales. It yields about twenty gallons a minute of a saline water, whose analysis by Professor Croft of the University of Toronto, a few years since, afforded the results given under 5. This water, which was

* Of the thirty-seven analyses of waters here given, ten have already appeared in Silliman's Journal [2] viii, ix, xi, but for the purposes of comparison it is thought well to reproduce them in the present connection. Of the others, the greater part have appeared in the *Geology of Canada*, but several are now for the first time in print.

TABLE I.—WATERS OF THE FIRST CLASS.

	1	2	3	4	5	6	7	8
Chlorid of sodium	17.8280	18.9158	38.7315	17.4000	29.8034	19.94	29.864	7.227
“ potassium .....	.0920	traces	traces	undet.	.3555	undet.	undet.	undet.
“ calcium	12.8027	17.5315	15.9230	9.2050	14.8544	6.49	12.439	2.102
“ magnesium	5.0737	9.5437	12.9060	9.4843	3.3977	1.95	7.33	1.763
Bromid of sodium .....	.1178	.2482	.4685	undet.	undet.	undet.	undet.	undet.
Iodid of “ .....	.....	.0008	.0133	“	.0042	.....	“	“
Sulphate of lime .....	.7767	.....	.....	.....	2.1923	1.77	.954	2.388
Carbonate of lime	traces	.0411	.....	.....	.....	.....	.370	.400
“ magnesïa .....	.....	.0227	.....	.....	.....	.....	1.287	.....
“ baryta and strontia.	.....	undet.	.....	.....	.....	.....	.....	.....
In 1000 parts	36.6911	46.3038	68.0423	36.0893	50.6075	30.15	52.251	13.829

first sought for the manufacture of salt, is now much used for medicinal purposes. Its strength seems subject to some variation, since a specimen from the same well in December 1861 gave me, by a partial analysis, chlorid of sodium 23.00, chlorid of calcium 9.66, chlorid of magnesium 2.40, sulphate of lime 1.75; = 36.81 parts in 1000. No. 6, examined at the same time, is from a second well sunk in 1861, not far from the last.

7, 8.—These are analyses of the waters from two borings in the Trenton limestone at Morton's distillery in Kingston. The analyses are by Dr. Williamson of Queen's College in that city, and were made probably ten or twelve years since. They have been recalculated so as to represent the whole of the sulphuric acid as combined with calcium. The first of these waters gave to Dr. Williamson both bromine and iodine, and the second was found to be sulphurous. These waters differ from the preceding in containing considerable amounts of earthy carbonates, and in this respect are related to those of the second class, while they still show a large predominance of earthy chlorids.

§ 37. The waters of the above table contain, besides chlorid of sodium and a little chlorid of potassium, large quantities of the chlorids of calcium and magnesium, amounting together, in several cases, to more than one half the solid contents of the water. Sulphates are either absent, or occur only in small quantities, and the same is true of earthy carbonates. Salts of baryta and strontia are sometimes present, while the proportions of bromids and iodids, though variable, are often considerable.

In the large amount of magnesian chlorid which they contain, these waters resemble the bittern or mother-liquor which remains after the greater part of the chlorid of sodium has been removed from sea-water by evaporation. The bitters from modern seas, however differ in the presence of sulphates, and in containing, when sufficiently concentrated, only traces of lime. The reason of this, as already pointed out in § 22, is to be found in the fact that in the waters of the present ocean the sulphates are much more than equivalent to the lime, so that this base separates during evaporation as gypsum.* But as shown in § 23 and § 24, the waters of the ancient seas, which held in the form of chlorid of calcium the greater part of the lime since deposited as carbonate, must have yielded by evaporation bitters containing a large proportion of chlorid of calcium. Such is the nature of the

* See farther on this point, Bischof, Chem. Geology, i, 413.

brines whose analyses are given in the above table, and such we suppose to have been their origin. The complete absence of sulphates from many of these waters points to the separation of large quantities of earthy sulphates in the Lower Silurian strata from which these saline springs issue; and the presence in many of the dolomitic beds of the Calciferous sand-rock of abundantly disseminated small masses of gypsum, is an evidence of the elimination of the sulphates by evaporation. The frequent occurrence of crystalline masses of sulphate of strontian in the Chazy and Black River limestones of this region, is also to be noted as another means by which the sulphates were separated from the waters of the Lower Silurian seas. From the proportions of chlorid of sodium, varying from about one third to more than two thirds of the solid contents of the above waters, it is apparent that in most cases the process of evaporation had gone so far as to separate a part of the common salt; and thus successive strata of this ancient saliferous formation must be impregnated with solid or dissolved salts of unlike composition. The mingling of these in varying proportions affords the only apparent explanation of the differences in the relative amounts of the several chlorids in waters from the same region, and even from adjacent sources. These differences are seen on comparing the waters from the different wells of St. Catharines, Hallowell and Kingston, with each other.

§ 38. The great solubility of chlorid of calcium renders it difficult to suppose its separation from the mother-liquors so as to be deposited in a solid state in the strata. The same remark applies to chlorid of magnesium. It is however to be remarked that the double chlorid of potassium and magnesium (carnallite) is decomposed by deliquesence into solid chlorid of potassium and a solution of chlorid of magnesium; and thus strata like those which at Stassfurth contain large quantities of carnallite (§ 22), might give rise to solutions of magnesian chlorid. This however would require the presence of a large amount of chlorid of potassium in the early seas. It will be observed by referring to the analyses above given, that the chlorid of magnesium sometimes surpasses in amount the chlorid of calcium; and sometimes, on the contrary, is equal to only one half or one fourth of the latter salt. While it is not impossible that the predominance of the magnesian chlorid in some waters may be traced to the decomposition of carnallite, it is undoubtedly in most cases connected with the action of solutions of carbonate of soda; the effect of which, as already pointed out, is to first

separate the soluble lime-salt as carbonate, leaving to a subsequent stage the magnesian chlorid (§ 18.) As this reaction replaces the calcium-salt by chlorid of sodium, it might be expected that there would be an increase in the amount of the latter salt in the water wherever the magnesian chlorid predominates, did we not remember that evaporation separates it from the water in a solid form; and that the two processes, one of which replaces the chlorid of calcium by chlorid of sodium, while the other eliminates the latter salt from the solution, might have been going on simultaneously or alternately. As the nature of the waters now under consideration shows that the process of evaporation had been carried so far as to separate the sulphate in the form of gypsum, and probably also a portion of the chlorid of sodium in a solid state, it is evident that we have not yet the data necessary for determining the composition of the water of the Lower Silurian ocean, as regards the proportions of the sodium, calcium, and magnesium which it held in solution; and we can only conclude from these mother-liquors, that the amount of the earthy bases was relatively very large.

§ 39. As already remarked in § 22, the mother-liquor from modern sea-water contains no chlorid of calcium, but, on the contrary, large quantities of sulphate of magnesia; the lime in the modern ocean being less than one-half that required to combine with the sulphate present. If however we examine the numerous analyses of rock-salt and of brines from various saliferous formations, we shall find that chlorid of calcium is very frequently present in both of them; thus supporting the conclusions already announced in § 24 with regard to the composition of the seas of former geological periods. The oldest saliferous formation which has been hitherto investigated is the Onondaga Salt-group of the New York geologists, which belongs to the upper part of the Silurian series, and supplies the almost saturated brines of Syracuse and Salina in New York. These, notwithstanding their great purity, contain small proportions of chlorids of calcium and magnesium, as shown by the analyses of Beek, and the recent and careful examinations of Goessmann. In the brines of that region the solid matters are equal to from 14.3 to 16.7 per cent., and contain on an average, according to the latter chemist, 1.54 of sulphate of lime, 0.93 of chlorid of calcium, and 0.88 of chlorid of magnesium in 100.00; the remainder being chlorid of sodium.*

* Goessmann. Report on the Brines of Onondaga: Syracuse, 1862 and 1864. Also Report on the Onondaga Salt Co.: Syracuse, 1862.

The nearly saturated brines from the Saginaw valley in Michigan, which have their source at the base of the Carboniferous series, contain, according to my calculation from an analysis by Prof. Dubois, in 100.00 parts of solid matters: chlorid of calcium 9.81, chlorid of magnesium 7.61, sulphate of lime 2.20, the remainder being chiefly chlorid of sodium. Another brine in the same vicinity gave to Chilton an amount of chlorid of calcium equal to 3.76 per cent.* In a specimen of salt manufactured in this region, Goessmann found 1.09 of chlorid of calcium; and in two specimens of Ohio salt, 0.61 and 1.43 per cent of the same chlorid. The rock-salt from the Lias of Cheshire, according to Nicol, contains small cavities, partly filled with air, and partly with a concentrated solution of chlorid of magnesium, with some chlorid of calcium.†

* Winchell; Silliman's Journal [2] xxxiv, 311.

† Cited by Bischof, Lehrbuch, ii, 1671. The results of the analyses by Mr. Northcote of the brines of Droitwich and Stoke in the same region (L. E. & D. Philos. Mag. [4] ix, 32), as calculated by him, show no earthy chlorids whatever, and no carbonate of lime, but carbonates of soda and magnesia, and sulphates of soda and lime. He regarded the whole of the lime present in the water as being in the form of sulphate. If however we replace in calculating these analyses, the carbonate of soda and sulphate of lime by sulphate of soda and carbonate of lime, we shall have for the contents of these brines, chlorid of sodium, with notable quantities of sulphate of soda, some sulphate of lime, and carbonates both of lime and magnesia; a composition which is more in accordance with the admitted laws of chemical combinations. From these results, it would appear that the earthy chlorids, which according to Nichol are present in the rock-salt of this formation, are decomposed by sulphates in the waters which, by dissolving it, give rise to the brines.

It is to be regretted that in many water-analyses by chemists of note, the results are so calculated as to represent the co-existence of incompatible salts. Of the association of carbonates of soda and magnesia with sulphate of lime, as in the analysis just noted, it might be said that I have shown that it may occur in the presence of an excess of carbonic acid. (Silliman's Jour. [2] xxviii, 174). By evaporation, however, such solutions regenerate carbonate of lime and sulphates of soda and magnesia; and by the consent of the best chemists these elements are to be represented as thus combined. But what shall be said when chlorid of magnesium, carbonate of soda, and silicate of soda are given as the constituents of a water whose recent analysis may be found in a late number of the *Chemical News*; or when bi-carbonates of soda, magnesia, and lime are represented as co-existing in a water with sulphates and chlorids of magnesium and aluminum? These errors probably arise from

§ 40. The brines from the valley of the Alleghany River, obtained from borings in the Coal formation, are remarkable for containing large proportions of chlorids of calcium and magnesium; though the sum of these, according to the analyses of Lenny, is never equal to more than about one fourth of the chlorid of sodium. The presence of salts of barium and strontium in these brines, and the consequent absence of sulphates, is, according to Lenny, a constant character in this region over an area of two thousand square miles. (See Bischof, Chem. Geol., i, 377.) A later analysis of another one of these waters from the same region, by Steiner, is cited by Will and Kopp, Jahresbericht, 1861, p. 1112. His results agree closely with those of Lenny. See also the analysis of a bittern from this region by Boyé (Silliman's Journal [2] vii, 74).

These remarkable waters approach in character to those of Whitby and Hallowell; but in these the chlorid of sodium forms only about one half the solid contents, and the proportion of the chlorid of magnesium to the chlorid of calcium is relatively much greater than in the waters from western Pennsylvania, where the magnesian chlorid is equal only to from one third to one fifth of the chlorid of calcium; the proportions of the two being subject in both regions to considerable variations.

In this connection may be cited a water from Bras d'Or, in the island of Cape Breton, lately analyzed by Prof. How, which contains in 1000 parts, chlorid of sodium 4.901, chlorid of potassium 0.650, chlorid of calcium 4.413, and chlorid of magnesium only 0.638, besides sulphate of lime 0.134, carbonates of lime and magnesia 0.085, with traces of iron-oxyd and phosphates; = 10.821. (Canadian Naturalist, viii, 370.) The analyses of European waters furnish comparatively few examples of the predominance of earthy chlorids.*

determining in the recent water, or in water not sufficiently boiled, the lime and magnesia which would by prolonged ebullition be separated as carbonates, together with portions of alumina, silica, etc. In the subsequent calculation of the analyses, these dissolved earthy bases being regarded as sulphates or chlorids, instead of carbonates, there remains an excess of soda, which is wrongly represented as carbonate, instead of chlorid, or sulphate of sodium.

* Lersch, Hydro-Chemie, Zweite Auflage: Berlin, 1864; *vide* p. 207. This excellent work, which is a treatise on the chemistry of natural waters, in one volume 8vo. of 700 pages, was unknown to me when I prepared the first part of this essay.

§ 41. We have already shown in § 38 how the action of carbonate of soda upon sea-water or bittern will destroy the normal proportion between the two chlorids of magnesium and calcium by converting the latter into an insoluble carbonate, and leaving at last only salts of sodium and magnesium in solution. A process the reverse of this has evidently intervened for the production of waters like that from Cape Breton, and some others noticed by Lersch, in which chlorid of calcium abounds, with little or no sulphate or chlorid of magnesium. This process is probably one connected with the formation of a silicate of magnesia. Bischof has already insisted upon the sparing solubility of this silicate; and he observed that silicates of alumina, both artificial and natural, when digested with a solution of magnesian chlorid, exchange a portion of their base for magnesia, thus giving rise to solutions of alumina; which, being decomposed by carbonates, may have been the source of many of the aluminous deposits referred to in § 9. He also observed a similar decomposition between a solution of an artificial silicate of lime and soluble magnesian salts. (Bischof, *Chem. Geology*, i, 13, also chap. xxiv.) In repeating and extending his experiments, I have confirmed his observation that a solution of silicate of lime precipitates silicate of magnesia from the sulphate and the chlorid of magnesium; and have moreover found that by digestion at ordinary temperatures with an excess of freshly precipitated silicate of lime, chlorid of magnesium is completely decomposed; an insoluble silicate of magnesia being formed, while nothing but chlorid of calcium remains in solution. It is clear that the greater insolubility of the magnesian silicate, as compared with silicate of lime, determines a result the very reverse of that produced by carbonates with solutions of the two earthy bases. In the one case the lime is separated as carbonate, the magnesia remaining in solution; while in the other by the action of silicate of soda (or of lime), the magnesia is removed and the lime remains. Hence carbonate of lime and silicate of magnesia are everywhere found in nature; while carbonate of magnesia and silicate of lime are produced only under local and exceptional conditions. The detailed results of some experiments on this subject are reserved for another place. It is evident that the production from the waters of the early seas of beds of sepiolite, talc, serpentine, and other rocks in which a magnesian silicate abounds, must, in closed basins, have given rise to waters in which chlorid of calcium would predominate.

§ 42. Of the waters of the second class whose analyses are here given, the first three occur, with many others of similar character, on the south side of the Ottawa river, below the city of that name. The remaining four are on the north side of the St. Lawrence, between Montreal and Quebec, where also similar waters abound. All of these springs rise from the Lower Silurian limestones of the region.

1, 2. These two waters are from the township of Plantagenet. The first is known as Larocque's, and the second as the Georgian spring. These waters were examined in 1849 and 1851. Two other springs have been observed in the same vicinity, one resembling Larocque's spring and containing borates, with a notable proportion of strontia, while the other is an alkaline-saline water of the third class.

3. Caledonia Intermittent Spring. This spring owes its name to the intermitting discharge of carburetted hydrogen which takes place from its waters. It is in the township of Caledonia, not far from Plantagenet, and near three other waters from the same township, to be mentioned in the next class. The water was collected in September 1847.

4. Lanoraie. This is from the seigniory of Lanoraie. It contains both baryta and strontia, and evolves an abundance of carburetted hydrogen. The water was collected in March 1851.

5. Is from a copious spring in the seigniory of Berthier, and was collected in July 1853.

6. Is from the township of Caxton, and yields six or eight gallons of water a minute, besides a great abundance of inflammable gas. The carbonic acid was found to equal 1.126 parts, of which .651, or more than one half is required for the neutral carbonates present. The water was taken from the spring in October 1848.

7. Is from the seigniory of St. Léon, and is a copious spring which, like the last, disengages inflammable gas. The carbonic acid was equal to 1.224 parts, of which .651, or not quite one half is required for the neutral carbonates found by analysis. The water was collected in October 1848.

8, 9. These are from two springs in the parish of Ste. Geneviève on the Batiscan River, and are remarkable for the large proportion of iodids which they contain. The first is known as Trudel's spring, and the second is at the ferry opposite to the church. The waters were collected in August 1853. Several other saline springs occur in the same neighborhood.

TABLE II.—WATERS OF THE SECOND CLASS.

	1	2	3	4	5	6	7	8	9
Chlorid of sodium....	11.6660	9.4600	12.2500	11.1400	8.0454	11.7750	11.4968	17.2671	11.5094
“ potassium...	.1040	.1040	.0305	.1460	undet.	.0800	.1832	.2409	undet.
“ barium.....	.....	.....	.....	.0303	.....	.....	.0019	.....	.....
“ strontium...	.....	.....	.....	.0185	.....	.....	.0019	.....	.....
“ calcium ...	.1364	.0443	.2870	.2420	.0466	.0503	.0718	.6038	.2264
“ magnesium..	.2452	.4942	1.0338	.2790	.0856	.3743	.6636	2.0523	.8942
Bromid of “	.0080	.0029	.0238	.0283	undet.	.0342	.0091	.0587	.0273
Iodid of “	.0052	.0017	.0031	.0052	traces	.0039	.0046	.0133	.0183
Sulphate of lime.....	.....	.1929	.....	.....	.....	.....	.....	.....	.....
Carbonate of baryta..	.....	.....	.....	.0106	.....	.....	.....	.....	.....
“ strontia..	.....	.....	.....	.0137	.....	.....	.....	.....	.....
“ lime....	.0330	.2980	.1264	.4520	.0470	.2160	.3493	.0120	.0180
“ magnesia	.8904	.3629	.8632	.4622	.8354	1.0593	.9388	.7506	.4464
“ iron.....	.0096	traces	traces	traces	.....	.0054	.0145	traces	traces
Silica.....	.0700	.0205	.0225	.0552	.....	.0479	.0865	undet.	undet.
Alumina	traces	undet.	traces	undet.	.....	.0050	.0145	“	“
In 1000 parts.....	13.1678	10.9814	14.6393	12.8830	9.0600	13.6513	13.8365	20.9987	13.1400
Specific gravity.....	1009.39	1008.78	1010.9	1009.42	.....	1010.36	1011.23	.....	.....

§ 43. Of the waters of the third class, which follow, the first four rise from the Trenton limestone, and occur on the south side of the Ottawa River, in the vicinity of the first three of the preceding section. The others are from the south side of the St. Lawrence below Montreal.

1, 2, and 3 are waters from Caledonia, and rise about two miles from the spring No. 3, of the last table. These waters were examined in September 1847. The first, which is known as the Gas spring, then yielded about four gallons of water a minute, and discharged in the same time about 300 cubic inches of carburetted hydrogen gas, whence its name. At a distance of four or five rods from this, are the second and third springs, known as the Saline and White Sulphur waters, yielding each about ten gallons a minute. The former affords a few bubbles of carburetted hydrogen gas, and is not at all sulphurous, while the latter contained a little sulphuretted hydrogen, equal to somewhat less than a cubic inch to the gallon. The temperature of the three waters was found to be respectively $44^{\circ}.4$, 45° and 46° F. The carbonic acid in 1000 parts of the Gas Spring was equal to .705; of which .356, or a little more than one half, is required for the neutral carbonates present. In the Saline spring there was found .648 of carbonic acid, being an excess of .292 over that required to form neutral carbonates; while in the Sulphur Spring, which contained in 1000 parts only .590 of carbonic acid, .349 are contained in the neutral carbonates, leaving only .141 towards the formation of bi-carbonates. For later analyses of these waters see § 46.

4. This, which is known as Gillan's spring, is from the township of Fitzroy, not very far from the last. Its waters were collected in July 1850.

5, 6. These two waters are from Varennes, and are about one hundred rods apart. The first is known as the Saline, and the second is called the Gas spring, from the large volumes of carburetted hydrogen gas which it disengages. The Saline spring contained in 1000 parts .920 of carbonic acid, of which .451 or nearly one half is required to form the neutral carbonates present. In the Gas spring was found .792 of carbonic acid, leaving thus .312 over that required to form neutral carbonates. The waters were collected in October 1848.

7. This is from Labaie du Febvre, and is known as Courchêne's spring. It evolves small quantities of carburetted hydrogen gas.

TABLE III.—WATERS OF THE THIRD CLASS.

	1	2	3	4	5	6	7	8
Chlorid of sodium	6.9675	6.4409	3.8430	6.5325	9.4231	8.4286	4.8234	5.9662
“ potassium .....	.0309	.0296	.0230	.1160	.1234	.0382	.0610	undet.
Bromid of sodium .....	.0150	.0169	.0100	.0217	.0126	.0046	undet.	undet.
Iodid of “ .....	.0005	.0014	traces	.0032	.0054	.0085	undet.	undet.
Sulphate of potash .....	.0053	.0048	.0183	.....	.....	.. ...	.....	.....
Phosphate of soda .....	.....	.....	.....	.0124	.....	.....	.....	.....
Carbonate of “ .....	.0485	.1762	.4558	.5885	.1705	.3260	1.5416	.6082
“ baryta .....	.....	.....	.....	traces	.0226	.0123	traces	.....
“ strontia .....	.....	.....	.....	“	.0140	.0096	“	.0250
“ lime .....	.1480	.1175	.2100	.1500	.3540	.3490	.2180	.1440
“ magnesia .....	.5262	.5172	.2940	.7860	.5433	.3559	.4263	.4756
“ iron	traces	traces	traces	traces	.0048	traces	.....	traces
Alumina .....	.0044	undet.	.0926	.0040	traces	“	undet.	undet.
Silica .....	.0310	.0425	.0840	.1330	.0465	.0540	.2120	.1140
In 1000 parts	7.7773	7.3470	4.9407	8.3473	10.7202	9.5868	7.2923	7.3330
Specific gravity	1006.2	1005.8	1003.7	1006.24	1008.15	1007.7	.....	.....

The water was collected in September 1852. Several other mineral springs occur in this vicinity, one of them belonging to this class, and others to the second and fourth classes.

8. This water, from the seigniori of Belœil, was collected in 1851.

§ 44. We shall now proceed to the springs which, in § 34, have been referred to the fourth class—and begin with three analyses of a mineral water from Chambly. Here, on a plateau, over an area of about two acres, the clayey soil is destitute of vegetation and impregnated with alkaline waters; which in the dry season give rise to a saline efflorescence on the partially-dried up and fissured surface. A well sunk here to a depth of eight or ten feet in the clay, which overlies the Hudson River formation, affords at all times an abundant supply of water, which generally flows in a small stream from the top of the well. Small bubbles of carburetted hydrogen are sometimes seen to escape from the water. The temperature at the bottom of the well was found in October 1861 to be 53° F., and in August 1865 to be nearly 54° F. The mean temperature of Chambly can differ but little from that of Montreal, which is $44^{\circ}.6$ F., so that this is a thermal water. Another alkaline and saline spring in the same parish has also a temperature of 53° F. The water of the spring here described has a sweetish saline taste, and is much relished by the cattle of the neighborhood. Three analyses have been made of its waters, the results of which are here given side by side. The first was collected in October 1851; the second in October 1852; and the third in August 1864, during a very dry season.

	I.	II.	III.
Chlorid of potassium,.....	undet.	·0324	·0182
“ sodium,.....	·8689	·8387	·8846
Carbonate “	1.0295	1.0604	·9820
“ lime,.....	·0540	·0380	·0253
“ magnesia,.....	·0908	·0765	·0650
“ strontia,.....	undet.	·0045	undet.
“ iron,	“	·0024	“
Alumina and phosphate,.....	“	·0063	“
Silica,.....	·1220	·0730	·0166
Borates, iodids and bromids, ..	undet.	undet.	undet.
In 1000 parts,	2.1652	2.1322	1.9917

A portion of barium is included with the strontium salt. The water contains moreover a portion of an organic acid, which

causes it to assume a bright brown color when reduced by evaporation. Acetic acid gave no precipitate with the concentrated and filtered water; but the subsequent addition of acetate of copper yielded a brown precipitate of what was regarded as apocrenate of copper. The organic matter of this and of many other mineral springs has probably a superficial origin. The carbonic acid was determined in the third analysis, and was equal in two trials to .903 and .905. The neutral carbonates in this water require .452 parts of carbonic acid.

§ 45. In the following table are given the analyses of several other waters which belong like the last to the fourth class.

TABLE IV.—WATERS OF THE FOURTH CLASS.

	1	2	3	4	5
Chlorid sodium.....	.0207	.0347	.3818	.3920	....
“ potassium...	.0496	.0076	.0067	.0318	.0169
Sulphate soda.....	....	traces.	.0215	traces.	.0188
“ potassium..	.0081	....	....	....	.0122
Carbonate soda.....	.1340	.1952	.2301	1.1353	.0410
“ lime.....	.1740	.0710	.0620	undet.	.2480
“ magnesia.	.1287	.0278	.0257	“	.0690
Iron, alumina, phos..	traces.	....	....	“	traces.
Silica.....	.0161	.0110	.0245	“	.2060
In 1000 parts.....	.5311	.3473	.7523	1.5591	....
In 10,000 parts.....	....	....	....	...	.6116

1. This spring was met with some years since in constructing a lock on the Richelieu River at St. Ours, and was enclosed in such a way that it is only accessible through a pump; so that it is impossible to determine the amount of water furnished by the spring, or its freedom from admixture. The water was obtained in November 1852, and is remarkable for the large proportion of potassium salts. 1000 parts of the water gave of alkalies determined as chlorids, 0.2250; of which 0.0565 parts, or 25.11 per cent, were chlorid of potassium. Another trial gave 24.52 per cent; while a portion of the water taken from the spring three

weeks earlier gave a larger proportion of alkalies, equal to 0.3400 of chlorids; of which 0.0596, or 17.53 per cent, were chlorid of potassium.

2. This spring occurs on the bank of the Jacques Cartier River, a little above Quebec. It is strongly impregnated with sulphuretted hydrogen, and appears to contain a considerable proportion of borates. It was collected for analysis in the summer of 1852.

3. This water is from a spring in the township of Joly, on the opposite side of the St. Lawrence, a few miles south from the last, and like it is sulphurous, and affords a strong reaction of boric acid. It was collected for analysis in July 1853.

4. A small area of marshy ground in the seignior of Nicolet, near the line of St. Gregoire, is, like the similar tract in Chambly, so impregnated with mineral water as to be destitute of vegetation. The water collected in a small pit dug in this locality in the autumn of 1853, was yellowish colored, and alkaline to the taste, and gave by analysis the above results. Several other alkaline springs occur in this vicinity. All of the preceding waters, with the exception of No. 2, which comes from out the Utica slates, rise, like that of Chambly, from the Hudson River formation.

5. This water, unlike the preceding, is that of a large river, the Ottawa, which drains a region occupied chiefly by ancient crystalline rocks, covered by extensive forests and marshes. The soluble matters which it contains are therefore derived in part from the superficial decomposition of these rocks, and in part from the decaying vegetation. The water which was taken at the head of the St. Anne's rapids, on the 9th of March 1854, before the melting of the winter's snows had begun, had a pale amber-yellow color from dissolved organic matter, which gave a dark brown hue to the residue after evaporation. The weight of this residue from 10,000 parts, dried at 300° F., was .6975, which after ignition was reduced to .5340 parts. As seen in the above table, one half of the solid matters in this water were earthy carbonates, and more than one third was silica, so that the whole amount of salts of alkaline bases was .088 (of which nearly one half is carbonate of soda); while the St. Ours water, which resembles that of the Ottawa in its alkaline salts, contains in the same quantity 4.248, or more than forty-eight times as much. The alkalies of the Ottawa water equalled as chlorids, .0900, of which .0293, or 32.5 per cent, were chlorid of potassium. The results of some obser-

vations on the silica and organic matters of this river-water will be given in part III. It will be observed that in the above table the figures given for the first five waters are for 1000 parts, while those of the Ottawa are for 10,000 parts.

§ 46. In this connection may be given the analyses of two similar springs from Vermont,—the Highgate and Alburg springs. The waters were sent me in October and November 1861, and the results have already appeared in “Geology of Vermont,” ii, 926. Both of these waters, when examined, were slightly sulphurous, and yielded the reactions of boric acid. The amount of carbonate of soda was estimated from the carbonate of baryta obtained by the process already mentioned in § 35.

	Highgate.	Alburg.
Chlorid of sodium .....	.402	140
Sulphate of soda .....	.042 .....	.024
Carbonate of soda .....	.235 .....	.230
“ lime .....	.024 .....	.036
“ magnesia .....	.010 .....	.022
Potash and borates	undet.	undet.
In 1000 parts .....	.713 .....	.452

§ 47. On the 5th January 1865, after a lapse of more than seventeen years, I again visited the three springs of Caledonia whose analyses have been given in the table § 43, and collected their waters for a second examination. The results of my recent analyses show that considerable changes have occurred in the composition of each of these springs, and tend to confirm in an unexpected manner, the theory which I long since put forward,—that the waters of the second and third classes owe their origin to the mingling of saline waters of the first class with alkaline waters of the fourth class. It will be observed that the three Caledonia waters in 1847 were all alkaline, though the proportions of the carbonate of soda were unlike. Sulphates were also present in all of them, though most abundant in the Sulphur spring, which, although holding the smallest amount of solid matters, was the most alkaline. In January 1865, however, the first and second of these waters had ceased to be alkaline, and contained, instead of carbonate of soda, small quantities of earthy chlorid, causing them to enter into the second class. They no longer contained any sulphates, but, on the contrary, portions of baryta and strontia. Only the Sulphur spring, which in 1847 contained the largest proportion of carbonate of soda and of sul-

phates, still retained these elements, though in diminished amounts, and was feebly impregnated with sulphuretted hydrogen. If we suppose these waters to arise from the commingling of saline waters like those of Whitby and Lanoraie, containing earthy chlorids and salts of baryta and strontia, with waters of the fourth class, holding carbonate and sulphate of soda, it is evident that a sufficient quantity of the latter water would decompose the earthy chlorids and precipitate the salts of baryta and strontia present; while an excess would give rise to alkaline-saline waters containing sulphate and carbonate of soda, such as were the three springs of Caledonia in 1847. A falling-off in the supply of the sulphated alkaline water has however taken place, and the result is seen in the appearance of chlorid of magnesium and of baryta and strontia in two of the springs, and in a diminished proportion of carbonate of soda in the Sulphur spring.

These later analyses being directed chiefly to the determination of these changes, no attempt was made to determine the potassium, iodine, and bromine. For the purposes of comparison, the two series of analyses are here put in juxtaposition; the elements just mentioned being included with the chlorid of sodium, and the figures reduced to three places of decimals. The precipitate by a solution of gypsum from the concentrated and acidulated water was regarded as sulphate of strontia, and calculated as such, but was in part sulphate of baryta.

TABLE V.—SHOWING THE CHANGES IN THE CALEDONIA SPRINGS.

	1. Gas Spring.		2. Saline Spring.		3. Sulphur Spring.	
	1847.	1865.	1847.	1865.	1846.	1865.
Chlor. sodium....	7.014	6.570	6.488	6.930	3.876	3.685
“ magnesium	....	.024	....	.026	....	....
Sulph. potash ....	.005	....	.005	....	.018	.021
Carb. soda .....	.048	....	.176	....	.456	.091
“ lime.....	.148	.096	.117	.095	.210	.077
“ magnesia..	.526	.455	.517	.469	.294	.228
“ strontia....	....	.009	....	.012	....	....
Silica.....	.021	.020	.042	.015	.084	.021
In 1000 parts....	7.762	7.174	7.345	7.547	4.938	4.123

In the recent analyses of these waters, the carbonic acid in the Gas spring was found to equal for 1,000 parts, .671; of which .278 were required for the neutral carbonates. The Saline spring contained .664 of carbonic acid; of which .290 go to make up the neutral carbonates. The Sulphur spring, in like manner, gave of carbonic acid .573; while the neutral carbonates of the water required only .191. All of these waters, in January 1865, thus contained an excess of carbonic acid above that required to form bicarbonates with the carbonated bases present; while the analyses of the same springs in 1847, showed, as we have seen in § 43, a quantity of carbonic acid insufficient for the formation of bicarbonates. The questions of this deficiency, and of the variation in the amount of carbonic acid in these and other waters, will be considered in the third part of this paper.

§ 48. The waters of our fifth and sixth classes, as defined in § 34, are distinguished by the presence of sulphates; the former being acid, and the latter being neutral waters. In the fifth class the principal element is sulphuric acid, associated with variable and accidental amounts of sulphates of alkalies, lime, magnesia, alumina, and iron. Apart from the springs of this kind which occur in regions where volcanic agencies are evidently active, the only ones hitherto studied are those of New York and western Canada; which issue from unaltered, and almost horizontal Upper Silurian rocks. (§ 31.) The first account of these remarkable waters was given in Silliman's Journal in 1829 (vol. xv, p. 238), by the late Prof. Eaton, who described two acid springs in Byron, Genesee Co., N. Y.; one yielding a stream of distinctly acid water sufficient to turn a mill-wheel, and the other affording in smaller quantities a much more acid water. The latter was afterwards examined by Dr. Lewis Beck (Mineralogy of New York, p. 150). He found it to be colorless, transparent, and intensely acid, with a specific gravity of 1.113; which corresponds to a solution holding seventeen per cent of oil of vitriol. No chlorids, and only traces of lime and iron, were found in this water, which was nearly pure dilute sulphuric acid. Prof. Hall (Geology of New York, 4th District, p. 134) has noticed, in addition to these, several other springs and wells of acid water in the adjacent town of Bergen. Farther westward, in the town of Alabama, is a similar water, whose analysis by Erni and Craw will be found in Silliman's Journal [2] ix, 450. It contained in 1000 parts about 2.5 of sulphuric acid, and 4.6 parts of sulphates, chiefly of lime, magnesia, iron, and alumina. In this, as in

the succeeding analyses, hydrated sulphuric acid, SO_3HO , is meant.

The earliest quantitative analyses of any of these waters were those by Croft and myself of a spring at Tuscarora, in 1845 and 1847, of which the detailed results appear in Silliman's Journal [2] viii, 364. This, at the time of my analysis in September 1847, contained in 1000 parts, 4.29 of sulphuric acid, and only 1.87 of sulphates; while the previous analysis by Prof. Croft gave approximatively 3.00 of neutral sulphates, and only about 1.37 of sulphuric acid. Similar acid waters occur on Grand Island above Niagara Falls, and at Chippawa.

All of these springs, along a line of more than 100 miles from east to west, rise from the outcrop of the Onondaga salt-group; but in the township of Niagara, not far from Queenston, are two similar waters which issue from the Medina sandstone. One of these is in the southwest part of the township, and fills a small basin in yellow clay, which, at a depth of three or four feet, is underlaid by red and green sandstones. The water, which, like those of Tuscarora and Chippawa, is slightly impregnated with sulphuretted hydrogen, is kept in constant agitation from the escape of inflammable gas. It contained in 1000 parts about two parts of free sulphuric acid, and less than one part of neutral sulphates. This water was collected in October 1849, and at that time another half-dried-up pool in the vicinity contained a still more acid water. Another similar spring occurs near St. Davids in the same township.

In connection with the suggestion made in § 31 as to their probable origin at great depths, it would be very desirable to have careful observations as to the temperature of these acid springs. When, on the 19th October 1847, I visited the Tuscarora spring, the water in two of the small pools had a temperature of 56°F. ; but on plunging the thermometer in the mud at the bottom of one of these it rose to $60^{\circ}.5$.

§ 49. It appears from a comparison of the analysis of Croft with my own that the waters of the Tuscarora spring underwent a considerable change in composition in the space of two years; the proportion of the bases to the acid at the time of the second analysis being little more than one third of that in the analysis of Croft. This change was indeed to be expected, since waters of this kind must soon remove the soluble constituents from the rocks through which they flow, and eventually become, like the water

from Byron, little more than a solution of sulphuric acid. The observations of Eaton at Byron, and my own at Tuscarora, show that half-decayed trees are still standing on the soil which is now so impregnated with acid waters as to be unfit to support vegetation. Reasoning from the changes in composition, it may be supposed that these waters were at first neutral, the whole of the acid being saturated by the calcareous rocks through which they must rise. It was from this consideration that I was formerly led to ascribe to the action of these waters the formation of some of the masses of gypsum which appear along the outcrop of the Onondaga salt-group (Silliman's Journal [2], vii, 175). That waters like those just mentioned must give rise to sulphate of lime by their action on calcareous rocks is evident; and some of the deposits of gypsum in this region, as described by good observers, would appear to be thus formed. So far however as my personal observations of the gypsums of western Canada have extended, they appear to be in all cases cotemporaneous with the shales and dolomites with which they are interstratified, and to have no connection with the sulphuric-acid springs which are so common throughout that region. (Silliman's Journal [2], xxviii, 365, and Geology of Canada, 352.)

§ 50. We have included in a sixth class the various neutral saline waters in which sulphates predominate, sometimes to the exclusion of chlorids. The bases of these waters are soda, potash, lime, and magnesia; which are usually found together, though in varying proportions. For the better understanding of the relations of these sulphated waters, it may be well to recapitulate what has been said about their origin; and to consider them, from this point of view, under two heads.

First, those formed from the solution of neutral sulphates previously existing in a solid form in the earth. Strata enclosing natural deposits of sulphates of soda and magnesia, sometimes with sulphate of potash, (§ 17, § 19,) afford the most obvious source of these waters. The frequent occurrence of gypsum however points to this salt as a more abundant source of sulphated waters. Solutions of gypsum may in some case exchange their lime for the soda of insoluble silicates, or this salt may be decomposed by solutions of carbonate of soda (§ 7, § 19). The decomposition of the sulphate of lime by hydrous carbonate of magnesia, as explained in § 21, is doubtless in many cases the source of sulphate of magnesia, which is more frequently than sulphate of soda a predomi-

nant element in mineral waters. In connection with a suggestion made in the section last cited, it may be remarked that I have since found that predazzite, in virtue of the hydrate of magnesia which it contains, readily decomposes solutions of gypsum holding carbonic acid in solution, and gives rise to sulphate of magnesia.

In the second place, sulphuric-acid waters, like those described in § 47, by their action upon calcareous and magnesian rocks, or by the intervention of carbonate of soda, may, as already suggested, give rise to neutral sulphated waters of the sixth class. It is evident also that waters impregnated with sulphates of alumina and iron from oxydizing sulphates, as mentioned in § 28, may be decomposed in a similar manner, and with like results.

Neutral sulphated waters generated by any of the above processes, are evidently subject to admixtures of saline matters from other sources, and may thus become impregnated with chlorids and carbonates. Indeed it is rare to find waters of the sixth class without some portion of chlorids; and a transition is thus presented to the waters of the first four classes, in which also portions of sulphates are of frequent occurrence. The presence of sulphates being one of the conditions required for the generation of sulphuretted hydrogen (§ 10), we find that the waters of the sixth class are very often sulphurous.

§ 51. Waters of the sixth class are very frequently met with in the palæozoic rocks of New York and western Canada, and are probably derived from the gypsum which is found in greater or less abundance at various horizons, from the Calceiferous sand-rock to the Onondaga salt-group. It is however not improbable that the sulphuric-acid waters which abound in this region (§ 48) may, by their neutralization, give rise to similar springs. In the waters of the district under consideration, the sulphate of lime generally predominates over the sulphates of the other bases, and chlorids are frequently present in considerable quantities. For numerous analyses of these waters, see Beck, *Mineralogy of New York*. The results of an examination of the Charlotteville spring, remarkable for the amount of sulphuretted hydrogen which it contains, will be found in Silliman's *Journal* [2], viii, 369. A copious sulphur spring which issues from a mound of calcareous tufa in Bra. / C.W., overlying the Corniferous limestone, is distinguished by the absence of any trace of chlorids; in which respect it resembles the acid waters of the fifth class from the adjacent region. A partial analysis of a portion of it collected in 1861, gave for

1000 parts, sulphate of lime 1.240, sulphate of magnesia .207, and carbonate of lime .198. From a slight excess in the amount of sulphuric acid, it is probable that a little sulphate of soda was also present.

Of waters of this class, in which sulphate of magnesia predominates, but few have yet been observed in this country. A remarkable example of this kind from Hamilton, C. W., was examined by Prof. Croft of Toronto, and described by him in the *Canadian Journal* for 1853 (page 153). It had a specific gravity of 1006.4, and gave for 1000 parts,

Chlorid of sodium.....	·5098
Sulphate of soda.....	1·6985
“ lime.....	1·1246
“ magnesia.....	4·7799
	<hr/>
	8·1128

The rocks exposed at Hamilton include the Medina sandstone and the Niagara limestone, with the intermediate Clinton group. Along the outcrop of the latter, crystalline crusts of nearly pure sulphate of magnesia are observed to form in many localities, during the dry season of the year. (*Geology of Canada*, p. 460.)

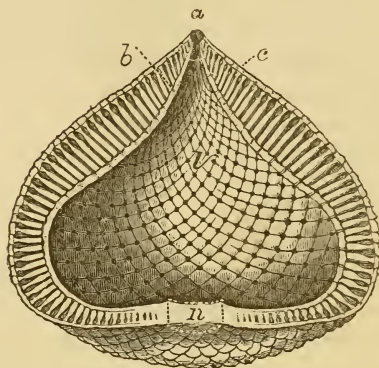
According to Emmons, the post-tertiary clays near Crown Point, on the western shore of Lake Champlain, are during dry weather covered with efflorescences of sulphate of magnesia, which impregnates several springs in the vicinity. The water of one of these, according to Emmons, had a specific gravity of 1014.0, and contained in 1000 parts, 18.78 of saline matter, which was chiefly sulphate of magnesia, with some sulphate of lime (cited by Beck, *Mineralogy of New York*, p. 252). The strata underlying the clays of this region belong according to the State geological map, to the Potsdam, Calciferous, and Trenton formations; but the source of the magnesian salt is, not improbably, to be found in the clays themselves.

In the third and concluding part of this paper it is proposed to notice briefly some of the more important points in the chemistry of the various waters which have been here described, and to inquire into their geological relations.—*Silliman's Journal*.

NOTES ON SOME OF THE MORE REMARKABLE GENERA OF SILURIAN AND DEVONIAN FOSSILS.

By E. BILLINGS, F.G.S.

Genus RECEPTACULITES, DeFrance.



1.

- 1.—Diagram of the structure of *Receptaculites* as it would be shown in a vertical section through a sub-conical species. *a*, the aperture in the summit; *b*, the endorhin or inner integument lining the central cavity; *c*, the ectorhin or external integument; *n*, the usual position of the nucleus; *v*, the great internal cavity. The unshaded bands running from the ectorhin to the endorhin represent the tubes.

The structure and zoological position of *Receptaculites* have been more or less elaborately investigated by Goldfuss, Eichwald, Roemer, Salter, Hall, and other eminent observers, and yet, owing to the imperfection of the materials, a great deal remains to be done before the various questions involved in the relations of this curious genus can be regarded as positively settled. Since the publication of Salter's paper in the first Decade of our Geological Survey, numerous specimens of several distinct species have been collected in the Silurian rocks of Canada, and I am, by the study of these, now enabled to furnish a few additional details. The principal new points are, the perforated structure of the internal integument, the existence (in most, if not in all, of the species) of a great central cavity and an orifice in the upper side. The flat watch-shaped specimens which are usually figured as constituting the whole of the body, are probably only the basal portion of the body-wall of the discoid species.

The genus may be described as consisting of organisms, which, when full grown and perfect, are of a discoid, cylindrical, ovate, or globular shape, hollow within, and usually, if not always, with an aperture in the upper side. In or near the centre of the lower side there is generally to be seen a small rounded protuberance, indicating, most probably, the position of the primitive cell or nucleus from which the animal commenced its growth. In some species the lower side is more or less concave, and often the nucleus is not at all elevated above the surface adjacent thereto. Its place, however, in the absence of any other guide, may generally be found by observing the point towards which the spiral lines or rows of plates on the outer surface converge. The body-wall is of a somewhat complex structure. It consists of three parts,—an external and an internal integument, and, between these, the peculiar tubular or spicular skeleton presently to be described. The external integument may be called 'the ectorhin,' and the internal 'the endorhin.'

The ectorhin is usually composed of numerous small rhomboidal plates closely fitting together, and arranged in curved rows which radiate in all directions from the nucleus outwards to the peripheral margin of the base, and thence, ascending upwards, converge to the edge of the aperture in the upper side. Two or three of those rows of plates (the precise number is not yet determined) originate in the nucleus, and, as they diverge from each other, new rows are introduced between them. The number of rows diminish again on the upper side according as they converge towards the apex of the fossil. The plates at and immediately around the nucleus, and also towards the centre of the upper side, are somewhat smaller than they are at the widest part or middle region of the body. It seems probable that, in some of the species, this integument was of a flexible, coriaceous consistence. In others the plates were solid. In *R. occidentalis* (Salter), when silicified specimens are treated with acid the plates are easily separable, and, therefore, although in close contact, they were not anchylosed together.

The endorhin is also composed of small rhomboidal plates arranged in curving rows; but it differs from the ectorhin in being perforated by numerous small circular orifices, one of which is situated at each point where the angles of four plates meet. From the centre of each of the plates of this integument there radiate four small canals, one proceeding straight to the middle of each of the sides of the plate, where it communicates with a similar canal.

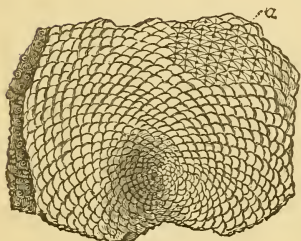
in the adjoining plates. Each one of these plates is, therefore, connected by these canals with the four plates in contact with it. The canals are excavated in the substance of the plates, and communicate with the central canal of the transverse tubes. The canals are not always perfectly circular, but are often flattened or irregularly circular. The endorhin varies greatly in the extent to which it is developed. In some specimens the plates are well-defined and rhomboidal, with perfectly circular pores at the angles. In others the plates are not at all defined, the ectorhin being one continuous integument without sutures, but always with the full complement of pores. The latter in such specimens are not all circular, but are variously shaped orifices, sometimes with rough edges. There are also specimens in which the endorhin consists of only a thin film capping, as it were, the tubes and inclosing the canals, the pores being proportionally larger than they are in those with well-developed plates. The end of each tube, in these specimens, forms an irregular, rounded tubercle instead of a rhomboidal plate.

The tubular skeleton above alluded to consists of numerous small, straight, rarely curved, cylindrical tubes or hollow spicula, placed parallel to each other and at right angles to the plane of the body-wall of which they form the greater portion. They connect, and at the same time keep asunder, the ectorhin and the endorhin. One of these tubes springs from the centre of each plate of the ectorhin: it is, at its base, or next to the ectorhin, very slender, but enlarges so as to attain its full thickness at about one fourth of its length, and then remains at the same diameter throughout until it reaches the endorhin, by a single plate of which its inner extremity is, as it were, capped. The outer extremity of each tube has four small slender stolons, one proceeding to each of the four angles of that particular plate of the ectorhin from the centre of which it (the tube) springs. It there seems to form a connection with the stolons of the three adjacent plates whose angles meet at that point. The stolons are so arranged that one of them always points inwards towards the nucleus, and another on the opposite side of the tube outwards or upwards. It is proposed to call these the radial stolons; they form continuous lines radiating in all directions away from the nucleus. The other two stolons of each tube project at right angles to the direction of the radial stolons; they form circles round the nucleus, and may therefore

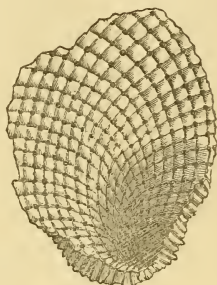
be called the cyclical stolons. The connection of all these different parts may be better understood by studying the following figures.



2.



3



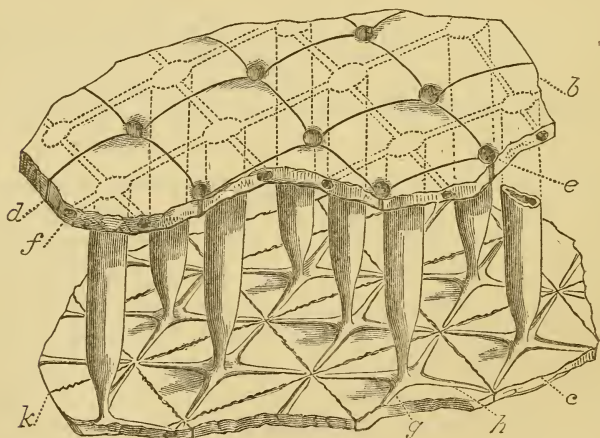
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2. A small portion of *R. occidentalis* showing the tubes. 3. A part of the lower side of the same species showing the nucleus and ectorhin. 4. A fragment of the same, showing the endorhin, the pores at the angles of the plates, and the nucleus, which, on this side, is usually deeply concave.

At the lower side of fig. 2, is shown the ectorhin and the apertures in the hollow stolons, broken off in the specimen. The apertures are slightly enlarged in the figure. In fig. 2, the usual aspect of the central portion of the lower side of this species is given. It will be seen that the greater number of the plates are not truly rhomboidal, but approach the form of a spherical triangle with two of the sides concave. This form of the plates frequently occurs. The convex side of such plates is always outwards towards the periphery of the fossil, and the acute angle formed by the two concave sides always directed towards the nucleus. This shows that the consolidation of the plates commenced at the nucleus and gradually extended outwards. In many specimens the plates are all perfectly rhomboidal, and in such they may have solidified simultaneously all over the body. One corner of the specimen at *a* is represented as denuded of the ectorhin, showing the various markings beneath, which will be hereafter explained by other figures. By fig. 4 is represented the ordinary

appearance of the endorhin of silicified specimens when cleared of the limestone matrix by treatment with acid. Although the pores have been seen in this species only, yet it seems quite probable that they occur in all others of the genus.

In the diagram fig. 5 the tubes are placed proportionately much farther apart than they are in any known species, in order to exhibit the structure with the greater clearness. The endorhin is drawn as if it were transparent to show the position of the tubes beneath it. The dotted lines give the outlines of the upper portions of the tubes, and also define the course of the endorhinal canals,—four radiating from the top of each tube. The endorhinal pores—one situated at each of the points where the angles of four plates meet—penetrate through the endorhin into the space between the tubes, and not into the tubes themselves, as might be supposed from a superficial examination. In the ectorhin the rough lines *k* represent the sutures between the plates; and it will be observed that they have the same direction as the endorhinal sutures in the upper part of the figure. The stolons have not the



5.

5. Diagram to explain the structure of the body-wall of *Receptaculites*. *b*, the endorhin; *c*, the ectorhin; *d*, suture between the plates of the endorhin; *e*, endorhinal pore; *f*, endorhinal canal; *g*, radial stolon; *h*, cyclical stolon; *k*, suture between the plates of the ectorhin.

same direction as the endorhinal canals, but are, as it were, turned one eighth round, so that the two directions are inclined to each

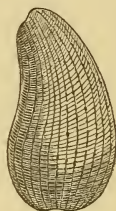
other at an angle of 45° . The stolons run along the inner surface of the ectorhin, but the endorhinal canals are excavated in the substance of the endorhin. The space between the tubes is almost always filled with the rock of the same kind as that in which the fossil is imbedded. In perfect specimens, the rock, while it was still in the condition of soft mud, must have found its way through the aperture in the upper side into the great central cavity, and thence through the endorhinal pores into the spaces between the tubes. In general the upper side or vault, as it may be called, over the central cavity is not preserved, and the specimen then consists of the whole or a portion of the base with the nucleus, as in figs. 3, 4. These are also filled with matrix; the soft ooze having entered not only through the pores, but also through the broken margin. It is probable that the animal lived with its base partly buried, a portion of the vault with the aperture projecting above the surface of the mud. During the life the central cavity was perhaps kept free from sediment by currents of water which the animal had the power of exciting. But as soon as the currents ceased (with vitality), the mud would enter freely. The vault would also soon fall to pieces, and the fragments of all those individuals of which it (the vault) projected above the surface of the sediment would be soon scattered, while the partly buried base would be preserved.

The specimen represented by fig. 6 is a fragment of the ectorhin of *R. calciferus*, from the Calciferous formation, Mingan Islands. It shows only the inner surface on which the stolons are still preserved, but the tubes are worn nearly to their bases. It is rare to find specimens in that condition; and this one was not suspected to be a *Receptaculites* for several years after its discovery, until a large portion of the base of an individual of *R. occidentalis* was found, which, by having been slowly weathered down from the upper side, retains the tubes over an area of several square inches, while a considerable space around the nucleus is covered with the squares formed by the stolons, precisely as in this example. Fig 7 is a cast of the inner surface of the ectorhin of *R. Oweni* (Hall), from the Lower Silurian rocks of Illinois. The integument itself is totally removed. The vertical lines are the impressions of the radial stolons, while the more irregular and slightly curved transverse lines are the imprints of the cyclical stolons. The dark points are the apertures of the cylindrical perforations in the rock once occupied by the tubes now entirely removed. On following any one of the lines, it will

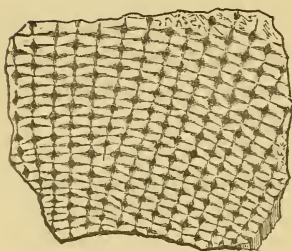
be seen that there is, between every two of the orifices, a point where two of the lines cross without an orifice at their intersection. Each one of these marks the point where the angles of four plates met. Four stolons also met at each of these points. This will be readily understood by comparing fig. 5. In specimens in this state of preservation we see no traces of the sutures between the plates, as the whole substance of the ectorhin—plates, sutures and all—is destroyed.



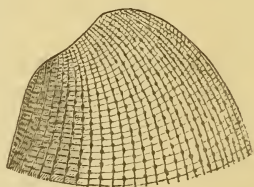
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7.



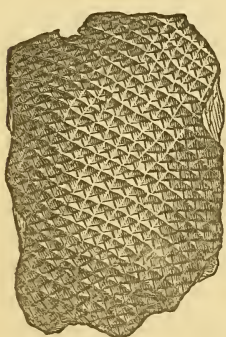
9.

6. Fragment of *R. calciferus* (Billings). 7. *R. Oweni* (Hall). 8 and 9 *Tetragonis Murchisonii* (Eichwald).

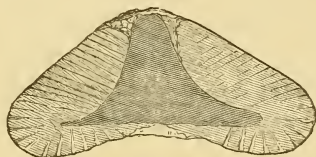
Fig. 8 is a reduced outline of *Tetragonis Murchisonii*, from Eichwald's 'Urwelt Russlands,' pl. iii, fig. 18. It does not show all the lines given in the original figure, as they could not well be represented on so small a scale. Fig. 9 is the upper part of the same figure, of the size of the original. The vertical lines are the impressions of the radial stolons, and the finer transverse lines the grooves of the cyclical stolons. By comparing fig. 7, it will be seen that the grooves in both figures have precisely the same arrangement; that is to say, the dark points, representing the openings of the cylindrical cavities, once occupied by the tubes, occur at each alternate crossing of the grooves. It would appear,

therefore, that Eichwald's genus *Tetragonis* was founded on a species of *Receptaculites*, with the ectorhin removed. The genus *Ischadites* also exhibits very similar markings, as may be seen by comparing the figures of *I. Kœnigii* (Murch.), on pl. 12, 'Siluria,' and the following of *R. Canadensis*.

The specimen represented by fig. 10 has been figured by me in the Geology of Canada, p. 304, under the name of *Ischadites Canadensis*. It is the cast of the inner surface of the ectorhin, and differs remarkably from the similar specimen of *R. Oweni* (*ante*, fig. 7). It is deeply pitted all over with sub-quadrangular or rhomboidal depressions, the form of each cavity being such as would be made by the impression of a small four-sided pyramid. In the bottom of each is a small rounded orifice, from which radiate three grooves to three of the angles of the square. These,



10.



11.



12.

10. *R. Canadensis* (Billings). 11. *R. Iowensis* (Owen). 12. *R. Jonesii* (Billings).

I have not the least doubt, are the grooves of three of the stolons. The absence of the fourth stolon may be accounted for in this way. Among the detached silicified tubes of *R. occidentalis* which are found in the sediment left at the bottom of the vessel, after dissolving specimens of limestone holding these fossils in acid, numerous specimens have been collected with only three stolons in contact with the plate or at the end of the tube, but with the fourth a small distance from the end. It is evident that in casts of the inner surface of the ectorhin of specimens with all the tubes thus constructed, there would be only the three grooves of the terminal stolons visible on the surface, the fourth being

buried beneath the surface. I have also ascertained that this fourth stolon is in *R. occidentalis*, one of the radials, and always when it can be seen *in situ*, the one pointing outwards away from the nucleus.

Fig. 11 is a vertical section of *R. Jonesii*, a small species which occurs in the upper part of the Lower Helderberg rocks of Gaspé. The shaded bell-shaped area is the central cavity. It is distinctly observed in several others of the same species. It will be seen that the body-wall in the vault above and on the sides of the cavity is thicker than it is in the base, but the tubes are much more slender. They here assume the form of the elongated connecting spicula of the true sponges. Fig. 12 is a similar section, though a specimen of *R. Iowensis* from the Trenton limestone at Ottawa. At *a*, the central cavity is distinctly shown, filled with the grey limestone matrix, which has also found its way between the tubes in the base of the fossil. The shaded portions *b b* are replaced by a reddish magnesian spar. The under side of the specimen is deeply concave, and the peripheral margin is so convex as to resemble a cylinder coiled into a ring. The aperture in one specimen of *R. Jonesii* is rounded, and resembles the umbilicus of an apple.

The figures given by different authors of foreign species show a considerable range of variation in the general form, and apparently also in the structure of the body-wall. The details given in this paper have been made out principally by the study of numerous specimens of *R. occidentalis*, which is undoubtedly congeneric with *R. Neptuni*, the typical form of the genus. In others, such as *Tetragonis sulcata* and *T. parvipora* (Eichwald), there appears to be a transition to species in which the ectorhin was a soft coriaceous integument, not distinctly plated, although connected with the interior by tubes or spicula. The genus *Tetragonis*, instead of becoming obsolete, might be retained for some of the species which have a structure different from that of *R. Neptuni*.

As to the zoological rank of *Receptaculites* there yet remains much diversity of opinion. At the present time the most ably supported view is that which places the genus in the Foraminifera near *Orbitolites*. Seen in this light, the diagram at the head of this paper would represent the soft and not the hard parts of the animal. If this be the true interpretation, then we must suppose that outside of the ectorhin there was a layer of shell, and another layer covering the endorhin, or lining the great central cavity.

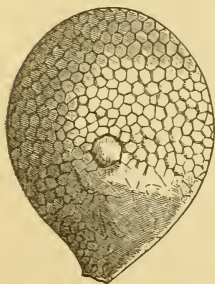
All the space between the tubes was also a compact mass of shelly substance similar to that of the Foraminifera. But not a vestige of any such shell has ever been discovered. The space between the tubes is invariably filled with the same kind of rock as that in which the specimens are imbedded, while all that is, in this paper, described as constituting the skeleton is in the same mineral condition as are the hard parts of the corals, crinoids and molluscs found buried in the same beds. In the ordinary limestone whenever the solid portions of the other fossils are replaced either by calcareous spar or silica, or partly by one and partly by the other, the skeleton of *Receptaculites* is always found converted into the same mineral substances. And again in the magnesian limestones where the hard parts of fossils are, in general, totally removed, so that the cavities once occupied by them remain empty, we find *Receptaculites* in the same condition. We have not the tubes themselves, but only the cylindrical perforations in the rock which they at one time filled, while the existence of the stolons is only indicated by grooves such as those represented in figs. 7, 9, 10. These facts seem to prove clearly that the space between the tubes was not filled with shell substance, but either empty, or entirely, or partly full of soft matter, which was immediately dissipated after the death of the animal, and its place occupied by the soft mud in or on which the creature lived. Were it otherwise we would now find the space in question a compact mass of calcareous spar or amorphous silex, while the tubes (or cells as they would be in that case) might be filled with limestone. In the magnesian specimens the ectorhin seldom, if ever, remains; and in species with flat plates the form (of the plates) can rarely be made out, the only markings on the surface being the grooves of the stolons. But where the plates were deeply concave the position of the sutures is indicated by more or less strongly elevated ridges enclosing rhomboidal depressed spaces with a tube-cavity in the centre. Fig. 10 represents a fragment of *R. Canadensis* in that state of preservation. The rhomboids in this case are not the plates themselves, but only their impressions. In describing such specimens, the tubes are sometimes spoken of as having rhomboidal openings, but this is an error; the tubes when perfect, as can be proved by hundreds of specimens, are not open at all, but completely closed, at one end by the ectorhin and at the other by the endorhin. They all, however, communicate with each other through the stolons and endorhinal canals.

Were the tubes of *Receptaculites* to be closely crowded together so that their walls would everywhere be in contact, and no space between them, then the structure would be similar to that of *Orbitolites*, but with the system of connecting stolons arranged on a different plan. The genus would then also closely resemble *Dactylopora*; but I do not yet see that the evidence is sufficient to prove clearly that the tubes are strictly the homologues of the cells of any group of the Foraminifera. They appear to me to be more nearly related to the connecting spicula of the Spongidae. Each tube with its cylindrical shaft, and plate at each extremity, resembles not remotely a birotulate spiculum. Or it might perhaps with more probability be described as consisting of two spicula united at their points. Thus the ectorhinal plate with the four stolons may be a peculiar form of the foliato-peltate spicula, of which many different kinds are figured by Bowerbank. The cylindrical shaft may be a spiculum approaching the acute or acerate varieties with its point inserted into the nucleus of the foliato-peltate spiculum. Most sponge spicula are hollow; and we know how often it happens in the structure of the animal kingdom that organs may at one time subserve one function, and elsewhere a very different function. The cylindrical cavity, which in the spicula of the ordinary sponges seems to be functionless, may in *Receptaculites* be transformed into a canal for the transmission of fluids. But although the cavities of all the tubes in *Receptaculites* communicate with each other through the endorhinal canals, and perhaps through the stolons also, they may not constitute a canal-system. The so-called tubes are extremely slender, and may be solid in some species.

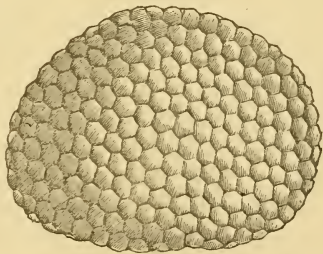
On comparison it will be found that the general form of *Receptaculites* and structure of its body-wall is almost precisely that of the seed-like body that plays so important a part in the development of *Spongilla*. This consists of a small ovate or spherical sac with an aperture on one side leading into the cavity within. The enclosing wall consists of a coriaceous membrane on the outside of which there are arranged, perpendicularly to the surface, numerous small birotulate spicula, exactly as the tubes of *Receptaculites* are arranged on the endorhin. The outer extremities of these spicula give off at right angles a number of small spines corresponding to the stolons above figured. These spines coalesce, and (if I understand the figures rightly) become connected together, so that they form by their union a plate similar to that of

Receptaculites, only that it is hexagonal. The plates of all the spicula enlarge until all come into contact, and thus an outer tessellated integument corresponding to the ectorhin is formed. In this stage a section through the seed-like body shews an inner integument (or endorhin), and an outer plated integument (or ectorhin), the two being separated and at the same time connected by the pillar-like cylindrical shafts of the spicula representing the tubes of *Receptaculites*. The space between the tubes is, according to some authors, filled with a gelatinous silicious matter; but Bowerbank says he did not detect this substance in the specimens examined by him. This little sac or cell is a *Receptaculites* in miniature, and it is also one of the embryonic stages of a sponge. When we consider that the full grown and adult individuals of many of the long extinct tribes of animals never attained in their structure a more advanced organization than that exhibited by the embryos of orders living at the present day, it does not seem surprising that we should find in the palæozoic rocks a sponge which although often of large size, never became more highly developed, than is the recent genus *Spongilla*, when it has only advanced to the sac-like stage above described. It is not intended to assert here positively that *Receptaculites* is a sponge, or to determine the question of its zoological rank one way or the other, but only to direct attention to such peculiarities in its structure as appear to me worthy of being taken into account in the investigation.

Genus PASCEOLUS, Billings.



13.



14.

13. *P. Halli*. From the Middle Silurian, Anticosti. 14. *P. globosus*.
Trenton limestone, Ottawa.

The fossils of this genus are of an ovate or globular form covered with an integument of small polygonal plates (?) and with one

or more circular apertures. Two species are at present known to occur in the Silurian rocks of Canada, both of which are above figured.

P. Halli is of an ovate form, from one to two inches in length and about one-fourth less, in width. At one end there is a narrow prolongation which, most probably, constituted the pedicle by which the body was attached to the bottom. No trace of any other point of attachment can be seen; and it is almost certain, therefore, that this smaller extremity is the base. A little below the mid-height of the body there is a small circular elevation which appears to mark the place of an orifice; but as the integument is not preserved in this part, it cannot, at present, be positively determined whether there was an aperture here or not. All that can be said is that there appears to have been an orifice where this elevation occurs. The specimens collected are all casts of the interior, but of the one figured a portion of the integument remains attached to the matrix. It is about one-third of a line in thickness, of a translucent, horny color, the surface covered with minute corrugated wrinkles just visible to the naked eye. No sutures can be distinguished, and the form of the plates can only be made out as so many obscure convexities on the outside. But where the integument is removed the cast shows the place of the sutures most distinctly, and that the plates were deeply concave on the inside. The polygonal spaces, in the above figure, represent only the outlines of the casts of the inner surfaces of the plates, and, as those are deeply concave, of course the whole surface of the cast of the fossil is covered with small convex elevations. In some places these are so exceedingly convex that they present the appearance of a mass of small globular cells just so much pressed together as to produce the hexagonal outline along the boundary of contact. Many of these elevations have a small round knob in the centre with an obscure ridge radiating to the middle of each of the sides, where they meet similar ridges from the other convexities. These markings are very obscurely developed, and in some places cannot be seen at all.

P. globosus only differs from *P. Halli* in being larger and of a spherical shape. The specimens are sometimes three inches across, but the common size is about two inches. They are, usually, more or less compressed and distorted, in general of a hemispherical shape, the base flattened as if the body had been a soft globular sac of matter which had settled down by its own weight. They are, however, occasionally found of a nearly spherical form. On

one side (the flattened side) of a specimen in the cabinet of Dr. J. A. Grant, of Ottawa, there is a small elevation which may have been the point of attachment. No orifices have yet been made out, but it must be observed that no specimen has been collected in which the whole of the surface can be examined. None that I have seen have a vestige of the integument remaining. The plates (or rather their impressions) are, in these specimens, for the greater part, strongly convex and precisely like those of *P. Halli*, only larger. In some they are partly concave and partly convex or flat. Individuals also occur which have them either convex, all flat, or all concave. Yet as these occur together in the same localities, I think them all one species. They have, as yet, been found only at the city of Ottawa in the Trenton limestone.

In one piece of shale scarcely a yard square, I collected about fifty individuals, but although they occur thus abundantly in certain spots, good specimens are exceedingly rare.

This genus was first described by me in the Report of the Geological Survey of Canada for 1857, p. 342, and placed among the fossils of uncertain class. The two species above figured are also there described. They have been on exhibition in the cases of our museum for the last ten years, and have been examined by a great many of the naturalists of all countries. But I do not think we yet know to what class they belong. *P. Halli* and *Ischadites Canadensis* are figured on p. 304, of the Geology of Canada, as members of the *Tunicata*. The latter, however, is a true *Receptaculites*. It is barely possible that the former may be a tunicate, but we have no positive evidence that it is.

Eichwald, in his *Lethaea Rossica*, has described and figured two species, *Cyclocrinus Spaskii* and *C. exilis*, which appear to me to be either congeneric with our two, or, at least, to belong to the same family. Both of Eichwald's species are small globular bodies covered with hexagonal or pentagonal plates. The plates of *C. Spaskii* have a tubercle in the centre and a number of obscure rounded ridges radiating to the sides. He says there is a small oral orifice on one side, and on the side opposite, a rudimentary pedicle. One of his figured specimens is covered with a tubular incrustation consisting of small cells which he considers to be a part of the integument itself. It may be, however, a coral. A fragment of one of the specimens of *P. Halli* from Anticosti is incrustated in precisely the same manner with what I take to be a species of *Stenopora*. Eichwald places his genus among the

Cystidea; but the more general characters, such as a jointed crinoidal column, the arms or pinnulæ, and the peculiar orifices which characterise all true Cystideans, are not forthcoming. It is barely possible that his view may be the correct one.

The fossil called *Sphæronites tessellatus* (Phillips), from the English Devonian rocks has the surface covered with hexagonal plates, and resembles, in general aspect, a species of *Pasceolus*. Mr. Pengelly has figured a specimen in the Geologist, vol. iv, which shows the interior, covered with a net-work of vertical and horizontal ribs, giving the appearance of the inner surface of the specimen of *Receptaculites calciferus* above noticed. He proposes a new generic nome, *Sphærospongia*, for it. If the specimen figured by him be truly of the same species as that described by Phillips, it would seem that an internal structure like that of *Receptaculites* is not inconsistent with an integument of hexagonal instead of quadrilateral plates. I do not see, however, how the net-work figured by Mr. Pengelly can be made to fit hexagonal plates in the way that the squares formed by the stolons of *Receptaculites* are adjusted.

M. M. Edwards and Haime have referred Eichwald's genus *Cyclocrinus* to the *Zoantharia*. Whether they are right or not with regard to the Russian species, I can most confidently assert that *Pasceolus* is not a coral. It may be allied to *Receptaculites*, but its true zoological position is quite undecided at present.

(To be continued.)

GOLD MINES AND GOLD MINING IN NOVA SCOTIA.

By HENRY F. PERLEY, Esq., Halifax, N. S.

As in other parts of the world where gold is now being produced, the discovery of the precious metal in Nova Scotia was made by accident. A man drinking at a small brook; a few specks of the shining metal found in the sands of the sea-shore; particles of gold in a piece of loose quartz,—first brought the auriferous character of the Tangier, the Wine-Harbor, and the Renfrew Gold-Districts into notice. In other localities, search was made among the quartz-boulders which had lain undisturbed and unnoticed for years, and they proving auriferous, led to the establishment of such localities into gold districts. It is somewhat strange that

the existence of these auriferous deposits should have remained so long undiscovered even by the road-maker or the agriculturist, and after the many scientific explorations of the country, which have been made during the present century, by men eminent in Geology and Mineralogy. Principal Dawson, in 1855, suggested the probability of the discovery of gold, and with some accuracy indicated the region in which it might possibly be found, but he made no search for it.

The first discovery of gold was made in the early part of the year 1860, on the Tangier River; and since that time, other localities have been discovered, nearly the whole of which are now being worked upon. During the excitement of first discovery, individuals fancied that fortunes were to be made speedily, by the aid of a shovel, a pick, a pan, and with the expenditure of but little capital. Mining-lots were laid off by the Government, fifty by twenty feet, for which high rentals were asked; and in one or more of these the miner, whether practical or amateur, expended his labor and his capital, and in the end all failed;—the practical man from the want of space on which to deposit the debris of his underground excavations; and the amateur, because his patience, his hopes of making a speedy fortune, and his capital, were all exhausted. Individual enterprise having thus proved unsuccessful, companies were formed; and the Government, seeing the absurdity of leasing such small areas, increased their size to 150 by 200 feet, and modified and improved the law relating to the Gold Fields. Even with these advantages, many companies failed or sold out to others; and now a large proportion of the mining areas in the province are held by companies raised and incorporated in Massachusetts and New York, having capitals ranging from \$100,000 to \$1,000,000. A number of these companies have proved to be stock-jobbing operations; speculators having taken advantage of an excitement created on the stock-markets of Boston and New York, to palm off unproductive and almost valueless properties; and to aid their operations, examinations and reports were made by able and scientific men brought for the purpose, who were capable of investigating thoroughly the geological phenomena and characteristics of the auriferous districts. It is to be regretted that their reports are only servicable to assist in the sale of stock, and add but little to the otherwise scanty information of the geology of the gold districts. The various companies at work have had indifferent success; a few are

carrying on operations and making a profit; whilst others barely pay expenses; but the whole are now suffering from a depreciation in the value of their stock, caused by the bursting of speculative bubbles thrown into the market, and wafted upwards by seductive scientific reports, by the exhibition of rich nuggets and massive bars of gold, and by wondrous tales of the yield to the ton of ore and of the expected profits. The question whether gold mining in Nova Scotia is a profitable and safe investment for capital, is still an unsettled one, though, judging from the past, it would appear to be both unsatisfactory and unprofitable.

The whole southern coast of Nova Scotia, from Cape Canso to Cape Sable, consists of altered or metamorphic rocks, such as slates, quartz-rock, gneiss, &c. This zone averages about thirty miles in width, and in it are found the gold-bearing quartz-veins for which Nova Scotia has now become noted, and from which a large amount of wealth is being derived. The aspect of the country is barren and sterile, the hills in many places being covered with a sparse and stunted growth of trees; huge boulders of granite, quartzite, or conglomerate abound, giving to the district under consideration the appearance of a country entirely unsuitable for agriculture. Prof. Dawson, in his 'Acadian Geology,' page 364, in treating on the Metamorphic district of the Atlantic coast, states, "With respect to the surface and industrial capabilities, the different rocks occurring in this district present very various aspects. The clay-slate often has a regular undulating surface and a considerable depth of shingley or clay soil of a fair quality, though usually deficient in lime. These slate-districts, however, contain beds of quartz-rock, which form rocky ridges, from which boulders have been scattered abroad, and which, by damming-up the surface waters, produce lakes and bogs, an effect also produced by the ridged structure of the slate itself, and the impervious sub-soil which it affords. Wherever, as for instance in North Queens and Lunenburg, the slate is sufficiently elevated for drainage, and not encumbered with surface stones, it supports fine forests and valuable farms. Where quartz-rock prevails, the soil is almost invariably extremely stony and barren. Instances of this occur in Southern Queens, near Halifax, and in the hills near St. Mary's River."

With regard to the position of this metamorphic band in the geologic scale, some doubt seems to exist. There is no positive evidence of its geologic age—no trace of a fossil has been found in

any of the slates or associated rocks.* Prof. Dawson favors the belief that they are metamorphic Lower Silurian rocks. It is evident to the observer that they are highly metamorphic, as well as changed from the horizontal position they once occupied, by upheavals which have thrown them into positions almost vertical; and that at the time of upheaval the innumerable quartz-veins which are now known to exist, must have been formed.

The general character of the geology of the district may be stated in a few words. It consists of thick bands of slate and quartzite, having a general east and west strike, and highly inclined. In several places, masses of granite project through these rocks, and in their vicinity the quartz-rock and clay-slate are usually replaced by gneiss and mica-slate, or other rocks more highly metamorphosed than usual. The general dip of the strata is about 60° , but it ranges in localities from the vertical to the horizontal. From the examinations of Mr. Campbell of Halifax, it was found that the strata in the metamorphic district have been folded or plicated no less than six times, and that the summits of the folds or the anticlinal axes thus formed, were denuded or abraded during the drift or glacial period. To quote from a report made by Mr. Campbell to the Provincial Government: "In all vertical sections hitherto made out across the rocks of the south or Atlantic coast of the Province, but one line of elevation, or anticlinal axis, is represented along the centre of a band of strata over thirty miles in breadth.† If this had, in reality, been the stratigraphical arrangement in the south coast-band, there would exist but a poor chance of many of its older strata being brought to the surface in lines of upheaval along the north coast of the Province, where so great an accumulation of newer schistose and Carboniferous rocks has taken place; for such an arrangement as one line of elevation in such a broad band of strata, would necessarily imply a vertical thickness of at least ten miles of beds.

"As it is, however, scarcely two miles in vertical thickness, the beds are brought in section to the surface, for they are brought up in six different lines of elevation or anticlinal axes, instead of one.

"By referring to the section attached [to the Report] it will

* Dr. Honeyman has recently announced the discovery of fossils supposed by him to be primordial; but they have not been described.—Eds.

† This is scarcely correct; though no attempt had previously been made to work out the details of the numerous folds or dislocations.—Eds.

be observed that the clay-state is superimposed on the quartzite as a distinct group, and not interstratified with it.

"The line on which this section is made extends from the Atlantic, at the south-east entrance of Halifax Harbor, to the Renfrew Gold-Fields, a distance of a little over thirty miles, intersecting the anticlinals mentioned. These anticlinals run nearly parallel with each other from the extreme western coast of the province to the sea-shore between Cape Canso and Liscomb Harbor. This gives them a curve, from the strike altering from east and west to south 60° east, and to the westward of Halifax, to the south-westward. They do not lie at equal distances apart, owing no doubt to the strata being folded up irregularly with different angles of dip."

That Nova Scotia has been subjected to glacial action, and that during the period of that action the summits of these anticlinals were denuded and swept away, is plainly apparent. Where the rock is exposed, whether by the removal of the boulder-clay or otherwise, it will almost invariably be found to have a smooth polished surface, and to be marked with furrows, scratches, and striæ, all of which must have been formed by the passage of heavy and hard substances over it. These scratches indicate the direction in which the moving masses passed over, and they are found to have a south-eastern direction over the whole province, modified of course by local circumstances.

The fact that this denudation has taken place, and the non-discovery of rich alluvial washings, have led to the belief that the major portion of the drift has been carried away and deposited in the Atlantic Ocean, forming the submarine banks which skirt the southern shore of the Province. This belief is further strengthened by the fact that gold is largely disseminated through the sands of Sable Island; this being the only point of those banks raised above the sea, and at the same time lying in the general direction of the drift.

Mr. Campbell does not suppose that the abrading force was sufficient to expose the whole of the quartz-veins on the strata, but that many exist which have a capping on the summits of the anticlinals. Where the veins are exposed in these abraded surfaces, they are found to dip to the north or south, as they lie to the north or south of the anticlinals. Thus, at Waverley, which is situated on the fourth anticlinal axis, the veins which have been opened are found all to dip to the north, proving them to be on the north side

of the anticlinal; while at Oldham, which is on the fifth axis, the veins are found dipping both to the north and south, which leads to the belief they lie on either side of the axis.

The rock most noticed in the mining districts is the quartzite—commonly called ‘whin’ by the miners. It is a strong compact rock of a grey color, consisting of finely granular quartz. It is supposed to be of immense thickness, for, according to Mr. Campbell, where it lies exposed to view in the cuttings of the railway from Halifax to Truro, and where measurements were made, it was found to be over one mile in depth.

The slate-rock which usually accompanies all the gold-bearing quartz-veins, is generally argillaceous; and, according to the authority of Prof. B. Silliman, not an example of talcose slate appears. His examinations only extended to the eastern portion of the Province, and if it does exist, it seems to have escaped his notice. Mr. Poole, who reported to the Provincial Government in 1862, on an examination which he made of the metamorphic district west of Halifax, states that he found talcose slate at La Have River and Ritchie’s Cove, and talcose slate with pyrites in quartz at the Cream Pots. Near Cranberry Head, in the county of Yarmouth, chloritic slate exists; pure chlorite, and quartz intimately coated with minute crystals of chlorite, are found abundantly at Tangier. The slates are generally found forming the lower or foot wall of the quartz-veins, whilst the hanging or upper wall is usually quartzite. In some instances both walls are of slate; but that both are of quartzite is of very rare occurrence. Sometimes it is found that a vein is split into two, by a third and narrow vein, having thin walls or partings of slate.

The associated minerals found are zinc, blende, iron pyrites, mispickel or arsenical pyrites, galena, and the yellow sulphuret of copper.

Both iron pyrites and mispickel are found in the quartz-slates and quartzite indifferently; and with the mispickel, gold is almost invariably associated, particularly at Montague, where large quantities of this mineral are found, in which gold may be plainly observed; indeed a lump can hardly be broken up without exposing to view particles of gold. Galena is found in small quantities, and some specimens have gold in admixture with it. Blende is found intimately mixed with the quartz, and sometimes lying on the quartzite at its junction with the quartz. Its presence is accepted as a good sign by the miners. The pyrites is often found

decomposed, and converted into peroxide of iron, and, by discoloring the adjacent rocks, often marks the outcropping of a vein.

The question may however be asked, are the veins of quartz in Nova Scotia true veins, or beds? Up to the present time no decision has been arrived at in reference to this subject; and it is to be regretted that the gentlemen who, during the past year, have visited the gold-fields to examine them geologically, have not made known their views on this point. That the quartz is found following the planes of cleavage is apparent; but whether the plane of cleavage is the true bedding of the slate, is not yet fully settled. If the dip and plane of cleavage are identical, then the veins of quartz must be termed true beds or strata; but if the dip and plane of cleavage do not coincide, then the quartz occurs in veins. A solution of this point can easily be accomplished, and will be of interest to the geological student.

The quartz-veins of Nova Scotia vary in width from one eighth of an inch to eight feet, though the general width is found to range from three to twenty inches. Experience has shown that the larger the veins, the poorer their yield in gold. On the property of the Waverley Gold-Mining Company at Waverley, there are three veins respectively, twenty-four and thirty and thirty-six inches in width, which are barren; while in their neighborhood, veins of from six to eighteen inches produce from thirteen to twenty penny-weights of gold to the ton of quartz. In the larger veins the quartz appears to be free from the foreign minerals already mentioned, of a milk-white color, very much laminated, and breaks into irregular masses; while the productive quartz varies in color, is pure and crystalline, breaks into more regular forms, and is intimately mixed with the minerals above alluded to.

Gold is not however entirely confined to the quartz-veins, but is often found mixed with the slates on the foot-walls, and in the partings in several veins. But whether it is found in the quartz, in the metallic sulphurets, or in the slates, it is always pure, and, where visible, is seen in the form of grains or nuggets, called 'sights' by the miners. In some cases, however, it is invisible to the eye, and can only be separated by crushing and amalgamation. It has been observed, that where a very large sight, or quantity of sights, is found, which would indicate increased richness in the vein, it most generally follows that for some distance or depth on either side of the rich spot the vein is almost barren.

Veins do not preserve their width as they descend: they are

found to vary greatly, sometimes gradually thinning out to a mere thread, and then increasing in size as a greater depth is reached. They are often split-up into two or more branches, or are greatly enlarged by the junction of cross-veins. Neither do the veins dip with any degree of regularity, many of them having three or four rates of dip, which renders the sinking of shafts a troublesome and oftentimes an expensive matter; for the shafts are sunk vertically through the earth to the bed-rock, and then generally driven with the vein, and always on the lower or foot-wall side. Faults occur in most veins, owing no doubt to dislocations of the strata; and instances are known where the vein has been cut entirely off, and thrown for some feet.

It is generally supposed that auriferous veins present the richest ore at the surface, and decrease in the value of their yield with the depth, until at depths ranging from one to two hundred feet they no longer pay for working. This opinion is countenanced by the highest French and English authorities, and is supported by a wide class of facts. In Australia very large sums were spent in deep sinking on veins which were productive at the surface, but when certain depths were reached they proved barren and unprofitable.

In 1859 and 1860, after the quartz veins of Victoria (Australia) had been for some time neglected, the received opinion that auriferous veins diminished in value with their depth was disregarded, and, judging from a few exceptional cases where veins had paid at depths of from two to four hundred feet, those veins that had proved rich at the surface or within a depth of one hundred feet, were again opened and active operations carried on. But it was found that the rule held good; and it is boldly stated, that there are not six veins in the colony of Victoria (in 1860) from which a sufficient quantity of gold had been extracted at a depth of four hundred feet to pay the cost of extraction. Sir Roderick Murchison has stated, that the rule prevails in auriferous countries "that the working of gold-bearing quartz is not remunerative excepting near the surface, the ore being concentrated in the upper parts of the lodes."

Whether this rule will hold good in Nova Scotia still remains to be proved. So far, varied success has been met with in different shafts, which have been sunk to depths reaching from eighty to one hundred feet. At Waverley a shaft is now down one hundred and eighty-five feet, and the quartz obtained at that depth proves richer than that obtained at or near the surface.

A fact respecting the distribution of gold in the vein-rock, has been established in the mines of Nova Scotia: it is, that the precious metal does not pervade the whole vein alike, but runs in bands or streaks, at different rates of dip or inclination, in different veins. Were this fact fully understood, miners would be enabled to calculate, from observations and measurements made in openings on the vein which they propose to mine, at what depth they may expect to reach the auriferous and paying portion of the vein in new shafts. The following extract from Hittell's "Resources of California" is in elucidation of this fact:—

"Most of the gold in a lode is usually in a rich streak near the foot-wall or lower side, as if the metal had settled down by its gravity. The rock near the hanging-wall or upper side of the lode is the poorest. Occasionally several rich streaks will be found in a lode—one streak with coarse particles, another with fine. All parts of a lode are not equally rich; but the gold is found in spots. A lode which is very rich in one place, may be poor in another not very far off; indeed, there is no auriferous vein in the state known to be rich for a long distance on the surface. The gold is found in streaks or *pockets*; the rich streak runs downward, or has a dip in the lode. It is a matter of very great importance to the miner to ascertain the direction of this dip, and here is the rule: Take out some of the vein-stone, and examine the wall-rock carefully. In most veins it will be found that the wall has little furrows, as though the lode had been pushed upwards. These furrows indicate the direction of the dip of the rich streaks. Pockets may be considered as interrupted streaks; and when one rich pocket is discovered, others may usually be found by going down into the vein in the proper direction, and that is ascertained in the same manner as for continuous streaks."

Among all the veins of quartz discovered, none has excited so much curiosity, or given rise to so much speculation on the theory of its formation, as the horizontally plicated or folded vein found on Laidlaw's hill in the Waverley district.*

The following description of this vein by J. Arthur Phillips, of London, will convey some idea as to the appearance of this peculiar vein:—

"The most remarkable deposit of auriferous quartz hitherto

* See a description and figures of them by Prof. Silliman in Silliman's Journal [2], xxxviii, 104.

found is undoubtedly that of Laidlaw's farm. The principal workings are situated near the summit of a hill composed of hard metamorphic shales, where openings have been made to the depth of from four to five feet upon a nearly horizontal bed of corrugated quartz of from eight to ten inches in thickness. This auriferous deposit is entirely different from anything I had before seen, and, when laid open, presents the appearance of trees or logs of wood laid together side by side, after the manner of an American corduroy road. From this circumstance the miners have applied the name of 'barrel-quartz' to the formation, which in many cases presents an appearance not unlike a series of small casks laid together side by side and end to end."

"The rock covering this remarkable horizontal vein is exceedingly hard; but beneath it for some little distance it is softer, and somewhat more fissile. The quartz itself is foliated parallel to the lines of curvature, and exhibits a tendency to break in accordance with these striæ."

"The headings, and particularly the upper surface of the corrugations, are generally covered by a thin bark-like coating of brown oxide of iron, which is frequently seen to enclose numerous particles of coarse gold, and the quartz in the vicinity of this oxide of iron is itself often highly auriferous."

Up to the present time this vein has not been found further to the eastward than the point of its first discovery, whilst it has been traced some eight hundred feet to the west, in all cases being overlaid with rock, and that again with earth, in some places to the depth of ten feet. Under the impression that the stratum in this locality either lay in its original horizontal plane of deposition, and had not been subjected to upheaval; or that after being uplifted it had become folded over into the position it occupies; or that it is the summit of an anticlinal axis; it was judged that other and parallel veins would be found at lower depths, underlying the vein exposed. Shafts were sunk to depths of over fifty feet, and exploring drifts run out at that depth, but without success; and it is doubted whether any other veins do exist. This is all the more singular when it is stated, that on the opposite side of Lake Thomas, a distance of only one quarter of a mile to the westward, the strata are upheaved at an angle of 80° and numerous veins of quartz are found, and afford profitable returns on being worked.

The discovery of gold in the conglomerate at Gay's River has

given rise to much speculation as to its origin in that matrix. The following description has been extracted from a letter from Mr. C. Fred. Hartt, to Principal Dawson, on this subject, a copy of which has been kindly furnished by Mr. Hartt :—

“ At Corbett’s Mills the clay-slates are overlaid unconformably by nearly horizontal beds of grey and red conglomerate grit, and sandstone of the Lower Carboniferous, probably of the age of the lower coal-measures. These are overlaid by a mass of drift of variable thickness, and beds of stratified sand and clay. These conglomerates are not Silurian, for they overlie unconformably the rocks of that age, and they are totally unlike any Devonian rocks occurring in the Province. Lying as they do on the margin of the Carboniferous basin, they agree perfectly with the conglomerates and sandstones of the Lower Carboniferous group, for they contain a few ill-preserved fossil-plants like those found in similar Carboniferous beds.

“ The under part of the bed of the conglomerate or grit, at its junction with the slates, is highly auriferous, the gold occurring principally in the form of flattened scales, sometimes a quarter of an inch in diameter, disseminated through the rock. Many fragments of conglomerate have been found, not a cubic inch in size, on the surfaces of which from twenty to thirty of the scales could be observed with the naked eye. In the workings now being carried on, levels are driven into the bank at the junction of the two formations; a foot or more of the under part of the conglomerate bed is removed, and washed in the common miner’s cradle and pan, and yields rich returns. Only one vein of quartz, one quarter of an inch in thickness, has as yet been discovered in the slates under the Carboniferous beds; it is highly auriferous, and has a strike of about north and south, and dips to the eastward about 70° .”

No alluvial washings to any extent exist in the Province at the present time. In 1861, the discovery of gold in the sands of the sea-beaches of the peninsula known as the Ovens, in the County of Lunenburg, created great excitement for a time; but this subsided as the returns gradually grew poorer, and by the end of the summer of that year the washings were exhausted. The gold found is not to be ascribed to deposition during the drift-period, but is probably derived from the cliffs which form the shores. These cliffs are about fifty feet in height, and are composed of bands of hard and soft laminated slates, with veins of auriferous

quartz, and bands of common and arsenical pyrites intermixed. The action of the elements in decomposing the pyrites, the effects of the sea-waves in crumbling the soft slates, together with the frosts of each succeeding year, all have a tendency to undermine and destroy the coast; and the debris thus formed is washed away during heavy gales, and, after a lapse of time, again appears in the shape of sand and gravel, together with the smaller and lighter particles of gold which have been released from their matrices.

During the present year applications have been made to the Gold Commissioner for areas on the Middle River, in Victoria County, Cape Breton, and after due examination it was proclaimed a gold district. Up to the present time all the gold produced is from alluvial washings, and it is spoken of as being 'coarse and nuggetty.' Very little is now being done in the district, and the excitement has died away.

To obtain the gold contained in the gangue the following processes are necessary, viz., calcination, crushing, amalgamation, retorting, and smelting. Many omit the first operation, but all the others are indispensable. A difference of opinion exists as to the benefit of calcination, some contending that the wear and tear of machinery in crushing 'raw' and unburnt quartz are equal to the cost of calcination. Quartz is either calcined by being piled into heaps in alternate layers of quartz and wood; or is placed in the same manner in kilns constructed for the purpose, each kiln holding from ten to fifty tons. The whole is thus submitted to the action of intense heat, the greater portion of the sulphur and arsenic components of the pyrites are volatilized, and the quartz itself is rendered friable, and easier to crush in the mills. It is affirmed that quartz thus calcined will give a larger yield per ton than the unburned quartz. The sulphur and arsenic being in a great measure driven off, the quicksilver amalgamates with the gold released from the sulphurets. On the other hand, it is affirmed, that the cost of fuel and transport to and from the kilns, and the interest on the cost of these, all amount to a larger sum than the presumed loss in gold, *plus* the wear and tear of the machinery. The method of calcination in use in Nova Scotia does not fully answer the purpose for which it is intended, viz., the decomposition of the sulphurets. The quartz as it is extracted from the vein, is thrown into the kilns, without being broken into small pieces so as to expose the pyrites contained in the interior of the masses; and it is therefore impossible that the

intended effect can be produced. Although the auriferous ores of Nova Scotia may be deemed pyritous, yet they are comparatively free when contrasted with the ores of Colorado. These are highly pyritous, and calcination or desulphurization is now being carried on to a great extent. In the process known as Keith's, the ores are first crushed to a fine powder, and then submitted to the action of fire by being drawn through a flue, and are deposited in chambers at the other end. By actual trial, one cord (128 cubic feet) of ore, weighing 14,700 lbs. weighed only 8871 lbs. after being submitted to this process; having lost 5829 lbs., which had passed away in vapor. That the yield of gold was increased may be learned from the fact that a cord of ore treated by the old process yielded at the rate of \$100 per cord, whereas after being desulphurized the yield was \$864,—nearly a ninefold increase.*

The quartz is brought from the kilns to the mill, and is there broken up into small pieces, either by hand or by means of a *cracker*. This machine consists of a heavy-recessed cast-iron bed-plate; two sides of the recess (which is about twelve inches deep) are vertical, and the other two are inclined towards each other. On the sloping faces are secured corrugated plates of cast iron. In the recess, working on a pin in its lower end, is a heavy iron block having corrugated plates on two faces. This block works backwards and forwards in the recess, and the quartz, being fed between the plates, is gradually crushed up, and falls out at the bottom. By the use of this machine a large quantity of quartz can be crushed in a day, better than it can be done by hand, and at a cheaper rate.

After being cracked, the quartz is submitted to the operation of crushing, two modes of which are in operation in the Province, viz., by stamps, and by Chilian mills. The stamps are of two kinds, square and revolving. In either case a *battery* consists of a box, which may be made of cast or wrought iron, or of wood faced with boiler-plate; the bottoms of both kinds being made of cast iron, and protected by small plates called *anvil-blocks*. In the *stamper-box* are placed either four or six stamps; a stamp

* The process here referred to as Keith's appears to be an imperfect form of that employed in the novel and ingenious methods of Messrs. Whelpley and Storer, of Boston, which seem destined to revolutionize the art of metallurgy. See, for a brief notice of them, Silliman's Journal [2], xxxvii, 401.—Eds.

consisting of a head, shoe, and rod, each stamp weighing from 350 to 700 pounds. The shoes are made of hard grey iron to withstand the wear, and they are replaced in the bottom of the head when worn out. The stamper-rods are firmly held by guides, and carry projecting pins or collars. A cam shaft, carrying as many cams as there are stamps, is worked by any motive power, and in its revolutions the cams are brought into contact with the pins or collars, and the stamps lifted and dropped in rotation. The difference between the square and revolving stamps is, that the heads of the square stamps are square, and their united areas are almost equal to the inside area of the stamp-box, and they merely rise and fall without any other motion. The revolving stamps have round heads and rods, and by the action of the cam on the collar as the stamps are lifted, a circular motion is given, which, continuing through the fall, is supposed to be more effective in crushing the quartz to a fine state, than the simple lift and fall of the square stamp.

The quartz is fed into the rear of the box in small quantities at a time, and it is there acted upon by the stamps. A constant supply of water, generally hot, to assist the amalgamation, is led into the boxes, and forms a paste with the crushed quartz. In front of the boxes is an oblong opening, which is covered with a wire-net, having from 160 to 200 holes to the square inch, and through this the whole of the crushed quartz must pass.

The Chilian mill, an improvement on the Spanish *arastra*, still in use in South America, consists of a bed about six feet in diameter, which may be either of cast iron or of some hard solid stone, surrounded by a sloping rim of stout sheet iron. On this bed, two edge-wheels revolve, and, as the quartz is fed under them, it is crushed and mixed with the water supplied into a thin paste. A constant supply of water is kept up, and the overflow carries away the siliceous particles which are held in suspension. Several of Howell's rotary crushers have been tried, but the whole have proved failures, and are laid aside.

The extraction of the gold from the paste is effected by means of quicksilver, and is termed amalgamation. There are many different appliances for producing this result in operation in the Province. A description of all the modes would occupy too much time; and it may therefore suffice to say, that in the Chilian mill the quicksilver is placed in the pan, and is brought into contact with the gold as it is separated from the quartz by the act of

crushing. In the stamps, a portion of quicksilver is placed in the stamper-box, and the paste, as it flows forth, is carried over plates of copper amalgamated with quicksilver; or is led directly into shaking-tables; passed over riffles, having mercury in the top riffles; over complex arrangements of copper cups containing mercury; through amalgamated pans, &c.; or combinations of two or more of these systems. In some mills, after the paste has passed through or over the amalgamating system, it is passed through a Chilian mill to recover any gold that may have passed away in the tailings. In others the tailings are carried over inclined tables covered with blankets, in the asperities of which the metals lodge by their gravity, while the silicious particles are washed away. These blankets are removed at intervals, washed of their contents, and then relaid. Or the tailings may be passed over a buddle, and the metallic portion thus collected. In either case, this is placed in barrels attached to a horizontal shaft, with a few pounds of mercury and a quantity of water, and the whole kept revolving for a number of hours. The yield of gold in this process is, however, generally very small. The tailings are then allowed to go to waste; the propriety of doing which, will be alluded to hereafter.

The question, can there be perfect amalgamation? is still unanswered. Many machines, simple or complex in their construction and arrangement, have been invented, each of which has been deemed the only perfect machine, and yet none is perfect. An arrangement by which the quartz crushed to a fine powder and freed from the sulphurets could be passed through a body of mercury so as to ensure contact with every particle of gold contained in the mass, and at the same time to avoid the loss of mercury, would be the best for amalgamation. A number of machines to effect this have been constructed, but have not proved successful. The great difference between the specific gravities of quartz, 2.60, and mercury, 13.5, renders it a difficult matter to pass successfully the lighter bodies through the denser.

That a large portion of the gold from the mines of Nova Scotia is lost and carried away in the tailings is well established; and with the systems of amalgamation in use, it would appear impossible to avoid a loss. In the Chilian mill the gold is ground to a fine powder, and may be seen floating on the surface of the water. Although its specific gravity is so great, no known means will cause it to settle, and it is carried away in the overflow. Under the stamps the quartz is crushed into fine particles, and adhering to

many of these may be observed, by the aid of a glass, minute specks of gold; these of course are washed away. Again, gold is intimately associated with the sulphurets, and is lost as the pyritous grains are swept away with the silicious particles; and even grains of gold are carried away by too copious a supply of water. At Lunenburg where the gold was washed out of the sands of the sea beach, great difficulty was experienced in obtaining amalgamation, owing to the particles of gold being covered with a film which entirely prevented a union with mercury. No doubt this coating was formed by the decayed organic matter brought by the waves.

Allusion has been made heretofore to the loss of gold by reason of a non-reduction of the sulphurets; and in elucidation of this point, the following assays were made on tailings taken from a mill at Waverly.

Assay No. 1; tailings selected from different parts of the tailings-bank. 100 grains showed a yield equivalent to 6 dwts. 8 grains of gold to the ton of 2000 lbs.

Assay No. 2. From 5 lbs. of tailings all the silicious particles were washed out, leaving the sulphurets, which only amounted to 3 oz. 11 dwts. 100 grains, and showed a result of 6 oz. 14 dwts. 1 gr. of gold, and 10 dwts. of silver, to the ton of 2000 lbs.

Assay No. 3; tailings as they were taken from the bed and reduced to a fine powder. 100 grains yielded the equivalent of 7 dwts. 16 grs. of gold, and 2 dwts. 14 grs. of silver, to the ton of 2000 pounds.

In considering the results of these assays, it is apparent that a great loss takes place in permitting the sulphurets to flow away. By assay No. 2 the sulphurets amounted to 3 oz. 11 dwts., being $\frac{1}{17}$ or 5.88 per cent of the mass, and the result of the assay showed an amount equal to 6 oz 14 dwts. 1 gr. of gold and 10 dwts. of silver per ton of 2000 lbs. Allowing the market value of gold to be \$19.75 per ounce, the value of a ton of sulphurets, setting aside the value of the silver in this instance, will be \$132.36. As it takes seventeen tons of tailings to produce one ton of sulphurets, it follows that each ton of tailings is worth \$7.78. By assay No. 3, the yield from the tailings taken as found, but triturated to a fine powder, is equal to 7 dwts. 16. grs. to the ton; this at \$19.75 per ounce, amounts to \$7.59. By assay No. 2 the value of a ton of tailings is shown to be \$7.78,—the two results closely agreeing.

The mispickel from Montague was analyzed for Prof. Silliman at

Yale College. It was first crushed, and sifted to separate the coarse gold, after which that portion which was finely disseminated was separated by roasting, fluxing, and cupellation. The results calculated for 2000 lbs. gave of coarse gold 0.5676, and of the diffused gold 0.2740; = 0.9419 lbs., or 13 oz. 12 dwts. 22. grs. of gold to the ton of mispickel. This gold contained only 3.34 per cent of silver.

The separation of the gold from the sulphurets must be a chemical process, and it is a question whether the cost of extraction may not exceed the value of the gold obtained. In the gold mines of Virginia and North Carolina, the surface of the tailings-bank is plowed over, and the sulphurets are thus exposed to the action of the weather; when a sufficient time has elapsed, the surface tailings are run through the mill. This is always found to pay expenses, and leave a profit. During the month of August the agent of the Chebucto Company of Waverley treated a quantity of tailings in this manner, and was surprised to find that the results would pay all expenses, and leave a balance.

After the lot of quartz has been crushed, the mill cleaned-up, and the whole of the mercury used is washed free from all silicious particles and sulphurets, it is the custom with some to allow the mercury to stand for some hours, when the amalgam settles to the bottom, and the free mercury can be poured off for future use; or the whole quantity may be subjected to pressure in chamois leather, when the superfluous mercury is forced out through the pores of the leather, leaving the amalgam in the shape of a silvery pasty mass; but whichever means may be adopted, a certain quantity of dissolved gold passes away with the mercury, which, it is said, is beneficial in promoting amalgamation in future operations.

The separation of the gold from the mercury is performed in the operation of *retorting*. The retort is a cast iron vessel, conical in shape, having a cover which is made to fit extremely tight, to prevent the escape of the fumes of the mercury. In the cover is inserted a bent iron tube. The amalgam is placed in the retort, the cover securely fastened down, and the whole apparatus placed in the fire and covered with fuel. So soon as the mercury begins to distill over, the end of the tube is plunged into cold water, and a small stream of water is allowed to fall on the tube itself; when the mercurial vapor condenses and assumes its original form. Heat must be kept up until all the mercury has passed over, when the

retort is removed from the fire, and, after being sufficiently cooled, is opened, and the gold removed. Great care must be taken in retorting, otherwise a loss of gold may take place, either by being partially melted and made to adhere firmly to the sides of the retort; or in case of too great a heat being applied at an early stage of the operation, the mercury is flashed as it were into vapor, and fine particles of gold are sprinkled and deposited over the inside of the retort, and even into the interior of the tube. Where the amalgam has been carefully cleaned, and care has been taken in retorting, the gold is obtained in one lump, having the shape of the bottom of the retort, and is of a clear bright yellow color; otherwise, it is dull and dirty looking, and may be seen sprinkled with grains of quartz and pyrites. Retorted gold is porous and spongy in appearance, and will occupy a much larger bulk than the same weight of smelted gold. It is often remitted by the agents of different companies in this state, but does not command the same price as smelted gold. In all returns made to the Provincial Government retorted or unsmelted gold is valued at \$18.50 per ounce, and smelted gold at \$19.50. Gold in bar commands a price in the market of from \$19.75 to \$19.80 per ounce. Retorted gold generally loses in weight by smelting, owing to the oxidation of any of the baser metals which may be alloyed with it; and by the total expulsion of the mercury used in amalgamation, a notable quantity of which oftentimes remains with the gold, when the retort has not been sufficiently heated.

It is to be regretted that the law for the management of the Gold Fields, does not extend to the establishment of a Government Assay Office, where gold could be smelted, its fineness determined, and the bar officially stamped. By this means all gold would bring a price equivalent to its fineness, and the purchaser be protected from fraud and imposition.

The Gold Districts proclaimed in Nova Scotia are eleven in number, viz: Wagamatcook in Cape Breton, Stormont, Wine Harbor, Sherbrooke, Tangier, Lawrencetown, Montague, Waverly, Oldham, Renfrew, and the Ovens at Lunenburg. Mining is being carried on to a small extent at Gay's River, on private lands

These districts are now the property of the Crown, all private rights having been re-vested; and areas, or lots measuring 250 feet by 150 feet have been laid off; the smaller dimension being on the strike of the veins. Areas may be taken up, by application

to the Chief Commissioner of Mines, or to the Deputy Commissioner resident in the district, and secured by the payment of two dollars, when a lease will be granted for a term of twenty-one years. Where gold is discovered on private lands, as at Gay's River, and the Government decline to re-vest the land, applicants for areas must first arrange with the proprietor of the land, in writing, for leave to enter and work, and, on the agreement being deposited with the Chief or the Deputy Commissioner, a lease will be issued.

By the covenants in the lease, the lessee must perform each year one hundred days' labor in each area ; but, if he holds ten, and less than twenty, he will not be required to perform during the first year more than three fourths of the days' labor above required ; if holding twenty or more, but less than thirty areas—only one half of the days' labor will be required ; and if holding thirty or more, only one quarter of the amount. The lessee must also on the first days of January, April, July, and October, make a return to the Commissioner showing the number of days' labor expended, and the number of tons of quartz raised during the preceding quarter. If quartz has been sold, all details must be given. He must show the weight of all quartz sent to a mill ; the name of the mill ; the yield of gold ; and also a statement of all gold which may be obtained in other ways than in a mill,—as, for instance, from alluvial washings, or by crushing by hand.

Lessees of areas, or parties not holding areas, wishing to erect a crushing-mill, must obtain a license to work such mill, and enter into bonds in the penalty of two thousand dollars for the payment of all royalty due the crown on gold obtained in the mill, and for a true and exact account of all quartz crushed, where from, by whom owned, the yield of gold, whether unsmelted or smelted ; and the amount of royalty due the crown, which amounts to three per cent. on the value of the gold obtained ; unsmelted gold being valued at \$18.50, and smelted at \$19.50 per ounce. These returns must be made monthly, and sworn to, and the royalty due paid over.

Although the owner of a mill may not be the owner of the quartz crushed in his mill, he alone is responsible for the royalty, and for making the returns ; on neglect or refusal to do which, the mill-license can be cancelled, and the bondsmen proceeded against in the Supreme Court for the recovery of any royalty which may be due.

In September of the present year, ninety-five mines were being

worked, giving employment to eight hundred and thirty-six laborers. Thirty-four crushing-mills were in operation, twenty-two of which are driven by steam power, and the remainder, or twelve, by water. The average wages paid will be about one dollar per day; but very many of the miners, particularly those from Great Britain, take contracts for sinking shafts, driving adits and drifts, and for getting out the quartz. Where quartz is crushed at a mill, the cost per ton for so doing varies from two to three and a half dollars.

The yield from all the mines for the year 1862 was 7,275 ounces; for the year 1863, 14,001 ounces; and for the three quarters ending October 1st, 1864, 14,565 ounces; making a total of 35,841 ounces, as the result of two years and three quarters' mining. Estimating this at \$19.00 per ounce (for the greater portion is unsmelted gold), the value will be \$680,979.

Assuming the return for the month of September 1864 as a fair exponent of the yields from the different districts, it will be found that, if ranked according to the yield per ton, they will stand in the following order:

	oz. dwts. grs.		
Montague.....	2	9	17
Sherbrooke	1	8	10
Tangier	1	5	13
Renfrew.....	1	4	18
Stormont (Isaac's Harbor).....	1	2	12
Wine Harbor	1	2	2
Waverley.....	0	18	6
Oldham	0	15	20

If ranked according to the total yield of gold during the month, they will stand thus:

	oz. dwts. grs.		
Waverley.....	855	3	3
Sherbrooke.	378	6	1
Wine Harbor.....	220	10	15
Oldham.	176	2	1
Montague	134	4	10
Renfrew.....	111	19	0
Stormont (Isaac's Harbor).....	99	17	6
Tangier	88	5	1
Other and unproclaimed Districts	10	4	3

Although the mines are worked, and the yield is annually increasing, still it may be doubted whether they are profitable fields for the investment of capital. An individual fortunate in

the possession of a single area, often reaps a rich return; while a company having a large working capital, and owning a large number of areas, will be unfortunate in obtaining results. Faults may occur in the veins, the rich streak may be passed through, and the vein becomes barren, or gradually thins out to a mere thread, in sinking upon it; the expense of sinking shafts and making adits, &c., in the hard rock; the cost of transporting the quartz to the mill, etc., all increase the expenditure, and the quartz obtained may thus not pay the cost of mining and crushing. A thin vein may produce a very large yield, and yet be unprofitable to work; while a thick and easily worked vein, though producing a low yield per ton, is often found profitable.

The following statement has been prepared from the return of the Chief Commissioner of Mines for the months of July, August, and September, 1864, and is intended to show the yield of the different districts per man employed. The return for the month of September has been used; the price of gold has been assumed to be \$19.00 per ounce, and the cost of crushing per ton to be \$2.50.

District.	Men employed.	Tons crushed.	Yield in ounces.	Value at \$19.00.	Crushing at \$2.50.	Yield per man.
Stormont.....	102	53	99	\$1881 00	\$132 50	\$17 14
Wine Harbor...	75	200	220	4180 00	500 00	49 00
Sherbrooke....	107	266	378	7182 00	665 00	24 48
Tangier.....	59	69	88	1672 00	172 50	25 41
Montagu.....	45	54	134	2546 00	135 00	53 50
Waverley.....	278	937	855	16245 00	2342 50	50 00
Oldham.....	80	222	176	3344 00	555 00	34 86
Renfrew.....	40	91	112	2128 00	227 50	47 50
Total.	786	1892	2062	39178 00	4756 00	43 94

In the above, deduction should be made to meet expenses of management, royalty, tools, machinery, &c.

The writer, not professing to be a geologist, has to acknowledge that he has drawn largely from Dr. Dawson's 'Acadian Geology,' and from the reports made to the Provincial Government, for much of the geological description contained in this paper.

[Accompanying this interesting communication was a collection of minerals from the gold-region of Nova Scotia, kindly presented by Mr. Perley to the Society. Maps and sections illustrating the paper, were also sent.]—*Communicated by the Natural History Society of New Brunswick.*

ON THE EXTRACTION OF COPPER FROM ITS ORES
IN THE HUMID WAY.

By THOMAS MACFARLANE.

In the last Report of the Geological Survey of Canada reference was made to the poor pyritous copper ores of the Eastern Townships; and with regard to the best method of utilizing them, it was remarked as follows: "It is much to be desired that some of the various methods which have been proposed for removing the copper in a soluble form, could be applied to these ores."* The importance of this question has by no means diminished, since the publication of the report alluded to. The recent discovery, in the neighborhood of Lennoxville, of several very promising beds of pyritiferous copper ore, the difficulty of concentrating these by any of the usual mechanical processes of ore-dressing, and the obstacles to the establishment of smelting-houses near to the mines for the production of ingot copper, all combine to render this subject one of somewhat more than ordinary interest.

The processes which have been from time to time proposed, and put into practical operation, for the humid treatment of copper ores are so numerous and diverse, that I shall not attempt to describe them minutely. I shall merely refer to some of the more important among them, and especially to those which bear some resemblance in principle to the method pursued in certain experiments which I have performed on a small scale, with various Canadian ores, in order to the extraction of the copper contained in them. The results of these experiments having been very satisfactory, I shall proceed to describe them, and, in conclusion, refer to the manner in which the method of extraction founded on them might be most advantageously carried out on a large scale.

1. One of the oldest modes of producing copper in the wet way is the precipitating it, by means of metallic iron, from the water of mines, or that resulting from lixiviating old waste-heaps in their neighborhood. These waters contain the copper in the form of sulphates, derived doubtless from the oxidation of sulphuret ores. This process is or was not long ago carried on at Schmölnitz and Neusohl in Hungary, at Moldava in Croatia, in Anglesea, and at Rammelsberg in the Lower Hartz.

* Geology of Canada, page 736.

2. Closely allied to this process is the one still followed at Faldal in Norway, where an artificial oxidation takes the place of the natural oxidation of similar ores. They are roasted in heaps, and then lixiviated.

3. At Stadtbergen in Westphalia, and at Linz on the Rhine, the vapors evolved in roasting various sulphurets are brought into contact with poor ores containing malachite, and with oxidized ores containing cupric oxide. After these have been acted on for several weeks, they are lixiviated in the usual manner.

4. Dilute muriatic and sulphuric acids, hyposulphite of soda, and even ammonia, have been proposed and occasionally used for dissolving out the copper of oxidized ores.

5. Much resembling the process mentioned under 2, is the method in which the oxidation is performed by calcining in reverberatory furnaces. At various Russian smelting works and in Mansfeldt this process is applied, but in no case does the extraction appear to be at all complete. A large quantity of the copper is removed in the soluble form, but fully as much remains in the residue, which is subject to further metallurgical treatment.

6. The first stage of Bankart's process is the same as the foregoing ones. Rich Cuban sulphurets are first calcined by themselves in reverberatory furnaces, and then lixiviated; the residues are mixed with a fresh portion of raw ore and again calcined. The peroxide of iron contained in the calcined ore causes the conversion into sulphuric acid of a portion of sulphur which would otherwise escape as sulphurous acid. The additional amount of sulphuric acid thus formed contributes of course to rendering the copper soluble. This principle is doubtless correct, but there appear to have been other circumstances which interfered with the practical application of the process.

7. Longmaid calcines pyritous ores with common salt, and then lixiviates. In his process there is doubtless a larger amount of copper rendered soluble than when the sulphurets are calcined alone; but the residues, even when abundance of sulphur is present, are far from being free from copper. The process which I have adopted in the experiments about to be described may be said to be a combination of the two last mentioned methods,—Bankart's and Longmaid's.

8. Henderson's process differs from Longmaid's merely in this particular, that the calcination is performed at such a temperature as to cause the volatilization of the copper in the form of a sub-

chloride. The latter is condensed and treated further. This process labors under the same disadvantage as Longmaid's with regard to copper in the residues.

Among the various processes just enumerated, those which are most advantageous in economical respects, and which are best suited to the local circumstances of Canada, are evidently those in which few or no extraneous substances are required to render the copper soluble, and in which the acid necessary to form the soluble salt of copper is derived from the oxidation of elements present in the ore itself. At first sight the simplest and possibly most efficient means of rendering the copper soluble would appear to be that of merely calcining the sulphuret ores and lixiviating the product. Almost all such ores, whether containing copper glance, purple copper, or copper pyrites, certainly yield by such treatment more or less of their copper in a soluble state; but the amount of the metal so yielded in proportion to the quantity contained in the ore, is invariably very small indeed. Even with ores which contain a very considerable excess of sulphur, the calcination must be very carefully conducted if the extraction is at all to approach completeness. In the first stage of calcination sulphurous acid is given off; in the second sulphate of iron is formed; during the third stage it is necessary to heat the charge rather strongly in order to decompose the sulphate of iron, and transfer its sulphuric acid to the oxide of copper. In so doing there is a danger of too much heat being applied, and even of the sulphate of copper being decomposed. It is therefore extremely difficult to regulate this process, and the disadvantages of its being performed at too low a temperature consist not only in the extraction being imperfect, but also in the deposition of basic salts of iron while the copper is being precipitated. In this way the latter becomes so contaminated that many specimens of copper produced by cementation do not yield by assay over 60 per cent of the pure metal.

These disadvantages are to a very great extent removed by the use of common salt. By its action the sulphate of iron first formed is decomposed at a low temperature, and sulphate of soda and chloride of iron produced. The latter seems to be easily decomposed, and its chlorine transferred, in part at least, to the copper. On treating the calcined product with water, a solution is obtained which is very pure, often containing merely a trace of iron, in which case the deposition of basic iron salts becomes impossible. But although common salt may remedy the defects here indicated,

it cannot make up for a deficiency of sulphur in the original ore; and with or without common salt that ore will be treated with the greatest advantage which contains the largest proportion of sulphur. In proof of this the two following experiments may be cited:

1000 grains of slimes from the Bruce Mines, containing 5.20 per cent. of copper in the state of copper pyrites, but no admixture of iron pyrites, were calcined with 100 grains of common salt. The result yielded to water 13.7 grains of copper. Hence only 37.9 per cent. of the copper was extracted.

500 grains of ore from Escott, containing 10.4 per cent. of copper and an admixture of iron pyrites, were calcined with 100 grains of salt. The product yielded to water 40 grains of copper. Consequently 76.9 per cent. of the metal was removed.

In reflecting on the necessity of a sufficient supply of sulphur, it occurred to me that any means which would facilitate the conversion of the sulphur into sulphuric acid, instead of allowing it to escape as sulphurous acid, would be of advantage if applied in such calcining operations as those here referred to. Having in former experiments* demonstrated that the addition of peroxide of iron increased the amount of sulphuric acid formed in such calcinations, it occurred to me that it might be possible even with an ore containing no more sulphur, in proportion to the copper, than copper pyrites, to convert so much of it into sulphuric acid, as would in the presence of common salt develop sufficient chloride to render the whole of the copper soluble. I accordingly calcined the following materials together:

200 grains copper pyrites.

400 grains ferric oxide.

200 grains salt.

800 grains in all.

The copper pyrites, which was from Escott, contained 23.5 per cent.; = 47 grains of copper. The residue after calcination weighed 657 grains, and on analysis gave—

Insoluble iron oxide.....	67.9
Insoluble cupric oxide.....	2.2 = 1.8 copper.
Sulphate of soda.....	10.1
Chloride of copper.....	3.4 = 1.6 copper.
Chloride of sodium (by difference.)...	16.4

100.0

* Canadian Naturalist, vol. vii, p. 196.

From this it appeared that in the residue there were present of copper—

In an insoluble state.... 11.82 grs. = 25.15 per cent.

In a soluble state..... 10.51 “ = 22.36 “

22.33 grs.

Amount of copper lost.. 24.67 “ = 52.49 “

47.00 grs.

The only way in which this extraordinary loss of 52.49 per cent. can be accounted for, is by supposing it to have been volatilized; and other circumstances confirm this view. The calcined substances contained 66.35 grains of sulphate of soda. Consequently 53.11 grains of common salt must have been decomposed, and 32.08 grains of chlorine liberated from it. Of this, 11.82 grains are found in combination with the copper in a soluble state. The remaining 20.26 grains were more than sufficient to form sub-chloride with the 24.67 grains of copper volatilized. The whole of the 32.08 grains of chlorine were not however sufficient to convert the forty-seven grains of copper contained in the ore into soluble protochloride.

From this experiment it became evident, 1st, that even with the use of a large quantity of peroxide of iron, it is difficult to treat copper pyrites so as to produce enough of sulphuric acid to render all the copper soluble; and 2nd, the calcination must be performed at as low a temperature as possible, in order to prevent the volatilization of the copper. The experiment was therefore performed a second time, care being taken to keep the temperature low. The same materials, in the same proportions, were used, and the product this time from the 800 grains weighed 792 grains, and contained—

Iron oxide and other insoluble matter.. 66.00

Sulphate of soda. 17.60

Chloride of copper..... 9.64 = 4.55 copper.

Chloride of sodium (by difference).... 6.76

100.00

Thirty-six grains of copper out of the original forty-seven were this time removed in a soluble form; equalling seventy-six per cent, instead of the twenty-two per cent, of the former experiment. Further, it appears that 139 grains of sulphate of soda were formed; and consequently 111 of chloride of sodium decomposed, and sixty-

seven of chlorine liberated. The latter quantity was sufficient to convert fifty-nine grains of copper into proto-chloride. It becomes therefore difficult to say why the whole copper contents, 47 grains, were not extracted. Since the temperature was kept very moderate, the only other cause which may possibly have affected the result unfavorably, was the continuing of the calcination beyond the proper point, and the consequent decomposition of proto-chloride into insoluble sub-chloride of copper.

In order to ascertain whether the copper unaccounted for in the last experiment remained in the residue or was volatilized, the following experiment was made.

200 grains copper pyrites.

500 grains iron oxide.

200 grains salt.

900 grains were mixed together.

The pyrites contained 23.6 per cent, equal to 47.2 grains of copper. The mixture was calcined at a low temperature until the evolution of sulphurous acid and then of chlorine ceased. The result weighed 911 grains, and contained—

Iron oxide and other insoluble matter....	67.33
Cupric oxide.....	1.87 = 1.5 copper.
Sulphate of soda.....	12.6
Chloride of copper.....	8.14 = 3.8 copper.
Chloride of sodium (by difference)	10.06
	<hr/>
	100 00

It is evident from this that seventy-three per cent of the copper contained in the original ore was rendered soluble, and that twenty-seven per cent was left in the residue insoluble, but whether in the state of sub-chloride or oxide I did not ascertain. If we calculate from the amount of sulphate of soda formed in this experiment, it would appear that but a very little more chlorine was developed than was necessary to take up the whole of the copper as proto-chloride, so that it is most reasonable to suppose that the copper which remained insoluble was in the state of oxide, and had never had an opportunity of uniting with chlorine. The result of the experiment as to the volatilization of the copper was decisive, inasmuch as the whole of the copper was found in the product; therefore none could have been sublimed. The experiment also indicated that in order to a perfect extraction, an excess of chlorine must be presented to the copper.

It will be recollected that the experiments just described were made with an ore poor in sulphur; containing no more of that element in proportion to the copper than is contained in copper pyrites. The results not proving satisfactory, I proceeded to experiment upon ores containing more sulphur, taking care always to keep the temperature very low, and to interrupt the calcination so soon as the developement of sulphurous acid had ceased, and while that of chlorine and other gases was going on. The following are some of these experiments, with their results:

500 grains ore from Escott, containing 10·4 per cent copper (and both iron pyrites and copper pyrites), were calcined with 500 grains of iron oxide and 200 grains of salt. The product weighed 1184 grains, and gave with water a solution from which iron precipitated 49·6 grains of copper. Since fifty-two grains were present in the ore operated on, it is evident that 94·2 per cent of the copper was removed in a soluble form.

500 grains ore from Escott, containing 4·5 per cent of copper, and a considerable amount of iron pyrites, were calcined with 100 grains of iron oxide and 100 grains of salt. The result weighed 618 grains, and when heated with water yielded a solution containing 22·2 grains copper. 22·5 grains were present in the original ore; hence 97·7 per cent of the copper was dissolved.

300 grains of the same Escott ore, with 4·5 per cent of copper, 300 grains of ore from Bruce Mines containing 8·7 per cent of copper (and no iron pyrites), 300 grains of iron oxide, and 300 grains of salt, were calcined until chlorine was strongly developed. The result treated with water gave a green solution containing thirty-six grains of copper. Since the ore used in this experiment contained 39·6 grains copper, 90·9 per cent of the metal was removed in a soluble state.

300 grains of Bruce Mine ore of 8·7 per cent, 200 grains of iron pyrites from Brockville, 300 grains of iron oxide, and 200 grains of salt were calcined in the manner above mentioned. The product gave with water a solution containing 27·1 grains copper. The ore contained only 26·1 grains, and the excess may have been derived from the iron pyrites. In this case, therefore, the whole of the copper of the ore was dissolved.

The same mixture as the preceding, calcined for a longer time, yielded only 14·5 grains of copper in a soluble state.

400 grains of Bruce Mine slimes of 5·1 per cent, 400 grains of iron oxide, 100 grains of pyrites from Brockville, and 100 grains

of salt yielded, on calcination, a product from which water dissolved 18.6 grains of copper. The ore contained 20.4 grains; hence 91.1 per cent of the copper were dissolved.

200 grains of Escott copper pyrites of 23.6 per cent, 100 grains of iron pyrites, 800 grains of iron oxide, and 200 grains of salt were calcined together. The product weighed 1349 grains, from which water dissolved 46.6 grains of copper. Consequently ninety-eight per cent of the copper contents of the ore were rendered soluble.

In order to prove that the iron oxide is essential to producing this favorable result, the last experiment was repeated, the iron oxide being excluded from the mixture. On calcining and lixiviating, only 33.4 grains of copper were dissolved; that is, seventy per cent only instead of ninety-eight per cent.

The foregoing experiments were performed on plates of fire-clay in the muffle of a cupelling furnace. The iron oxide used was prepared by calcining iron pyrites with salt, and then lixiviating and drying. The following trials were made in a manner approximating more to the method that would necessarily be adopted in carrying out the process on a large scale. The mixtures were merely stirred on an iron plate lying upon two ignited billets of wood in a common stove. And further it will be seen that the oxide of iron necessary in the process was obtained from the ore experimented on. This ore was from the Capel Mine near Lennoxville, and had the following chemical composition:

Copper	8.60
Iron	30.31
Sulphur (by difference).....	34.34
Silica and argillaceous matter.....	26.75
	<hr/>
	100.00

These figures correspond to the following mineralogical composition:

Copper pyrites	24.72
Iron pyrites.....	49.79
Quartz, &c.....	26.75
	<hr/>
	101.26

It may be said that in round numbers this ore consisted of one half iron pyrites, one fourth copper pyrites, and one fourth rock. The first calcinations made with it were principally for the purpose of obtaining the necessary iron oxide. Nevertheless, the quantity of copper extracted was at the same time determined.

10,000 grains of the ore were first calcined with 2,000 grains of salt, and without oxide of iron. The result weighed 10,860 grains. Water extracted from it 0·8 per cent of copper, and diluted sulphuric acid dissolved further a quantity of flocculent matter containing 1·8 per cent. Of the 860 grains copper contained in the original ore there were therefore,

Dissolved by water.....	86·88 grains = 10 per cent.
Dissolved by dilute acid.....	195·48 " " 22 "
Left in the residue.....	577·64 " " 68 "
	<hr/>
	860·00

The product of the foregoing experiment after lixiviation and drying assayed 6·4 per cent. copper. A second calcination was performed with it and other substances having copper contents, as follows :

400 grains lixivated product of above experi-	
ment containing 6·4 per cent.....	= 256 grains copper.
2000 grains fresh ore of 8·6 per cent.....	= 172 "
1200 grains salt.....	
	<hr/>
7200 grains mixture with.....	428 grains copper.

After being calcined in the usual manner the whole weighed 7850 grains, and contained four per cent of copper soluble in water slightly acidulated with sulphuric acid, and 1·11 per cent of copper insoluble therein. Of the 428 grains there were therefore,

Dissolved	314 grains.
Left insoluble.....	87 "
Unaccounted for.....	27 "
	<hr/>
	428 grains.

Thus 73·3 per cent of the original copper contents were obtained in a soluble form.

The product of the foregoing experiment was, as in the first case, lixiviated and dried. It then contained $1\frac{1}{2}$ per cent of copper, and was calcined a third time, with fresh ore and salt in the following proportions :

4800 grains residue with $1\frac{1}{2}$ per cent....	= 64·0 grains copper.
2400 grains fresh ore of 8·6 per cent.....	= 204·5 "
1440 grains common salt.....	
	<hr/>
8640 grains, containing.....	270·4 grains copper.

This mixture was treated in the usual manner. The product weighed 8900 grains, and contained

Soluble.....	2.77 per cent.	= 246 grains copper.
Insoluble.....	.25 "	22.2 " "
Unaccounted for.....	1.3 "	" "
	<hr/>	270.4 " "

Thus 91.4 per cent of the copper contained in the ore originally used was recovered in a soluble form.

The residue from the experiment last described, after thorough lixiviation and drying, contained 0.44 per cent copper. Now very few of the slags from copper furnaces contain less than this per centage, and the refuse products of ordinary ore in dressing-operations seldom assay less than 1.5 per cent. In having produced therefore a residue containing as low a percentage as the above, it may be assumed that a point was raised where its copper contents might be disregarded. This residue consists, however, almost exclusively of iron oxide and the earthy matrix of the ore, and by virtue of the former is of value for mixing with fresh ore to produce the oxidation of the sulphur, and the consequent extraction of the copper contained therein. In order to test its usefulness in this respect a fourth calcination was made, with the following mixture:

2000 grains residue of 0.44 per cent	= 8.8 grains copper.
1000 " fresh ore of 8.6 "	= 86 "
600 " salt.....	
<hr/>	<hr/>
3600	94.8 grains copper.

The product weighed 3710 grains, and contained as follows:

Iron oxide and insoluble matter.....	72.13
Cupric oxide insoluble in water and dilute sulphuric acid... ..	.27 = 0.22 copper.
Cupric oxide soluble in dilute sulphuric acid .....	.13 = 0.11 "
Sulphate of soda.....	19.22 = 4.33 sulphur.
Chloride of copper.....	4.7 = 2.22 copper.
Perchloride of iron.....	1.42
Chloride of sodium, by difference.....	2.13
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	100.00

Of the 94.8 grains copper contained in the original ore, there were consequently

Dissolved by water.....	82.36 grains = 86.88 per cent.
Dissolved by dilute acid..	4.08 " = 4.3 "
Left in residue.....	8.16 " = 8.6 "
Unaccounted for .....	.20 " = .22 "
	<hr/>

94.80

If however we neglect the 8·8 grains copper contained in the residue used, which it is perfectly reasonable to do, then 95·7 per cent. of the copper in the ore is dissolved in water alone, and the whole of it on the additional use of a slight quantity of dilute sulphuric acid. One of the most striking facts deducible from the results of this experiment is that 46·64 per cent of the sulphur contained in the original ore was converted into sulphuric acid, and then into sulphate of soda. The amount of chlorine liberated by the formation of such a large quantity of this salt, must have been greatly in excess of what was necessary to render the copper soluble.

On account of this latter circumstance I attempted to reduce the quantity of salt used, and made four calcinations in the proportions of two parts of residue, one part of fresh ore, and one fourth of a part of salt. The ingredients, used with their copper contents, were as follows.

	1.	2.	3 & 4.
	GRS.	GRS.	GRS.
Residue.....	2000 with 8·8 Cu	1500 with 6·6 Cu	2000 with 20 Cu
Fresh ore.....	1000 " 86·0 "	750 " 64·5 "	1000 " 86 "
Salt.....	250 "	175 "	250 "
	3250 with 94·8 Cu	2425 with 71·1 Cu	3250 with 106 Cu

The products of these four experiments contained of copper respectively:

	1.	2.	3.	4.
	GRS.	GRS.	GRS.	GRS.
Soluble in water.....	59·11	40·5	62·22	66·00
Soluble in dilute SO ₃	14·69	7·3	3·60	10·00
Insoluble.....	} 21·00 {	7·3	18·18	17·21
Unaccounted for.....		16·0	22·00	12·79
	94·8	71·1	106·00	106·00

These results were by no means encouraging, yet the quantity of salt was quite sufficient for chloridizing the copper. One fact must however be mentioned with regard to these trials; they were very diligently stirred during the calcination.

No other resource was left but to return to experimenting with a larger quantity of salt. Accordingly the following ingredients were mixed and calcined :

2950 grains residue of 1·0 per cent.	=	29·5 grains copper.
1500 " fresh ore of 8·6 "	=	129·0 "
750 " salt.....		
5200 grains containing.....		158·5 grains copper.

They gave a product weighing 5270 grains, and containing

2.33 per cent Cu soluble in water	= 122.79
0.22 " " in dilute acid	= 11.59
0.33 " insoluble	= 17.16
Unaccounted for	= 6.96
	<hr/>
	158.50

Neither was this result extremely satisfactory. This mixture also was stirred diligently during the operation.

In order to ascertain whether the stirring exercised any injurious effect upon the completeness of the extraction, the following mixture was calcined :

2000 grains residue of 1.1 per cent	= 22 grains copper.
1000 " fresh ore of 8.6 "	= 86 "
500 " salt.....	

3500 grains containing..... 108 grains copper.

The operation was performed with as little stirring as possible, and the result weighed 3800 grains, containing

2.55 per cent soluble in water	= 96.90 grains copper.
.22 " " in dilute acid	= 8.36 "
.22 " left insoluble	= 4.18 "

109.44

It will be seen that this calcination was eminently successful, and that all the copper contained in the fresh ore was extracted. It was therefore very evident that diligent stirring was injurious.

Encouraged by this result I repeated the calcination with the smaller quantity of salt which I had previously used; the mixture being left almost wholly undisturbed during the operation. The ingredients were

2000 grains residue of 1.1 per cent	= 22
1000 " fresh ore of 8.6 "	= 86
250 " salt.....	

3250 grains with..... 108 grains copper.

They gave on calcination a product of 3405 grains, containing 2.77 per cent, equal to 94.31 grains copper soluble in water; a result conclusively establishing that the more undisturbed the materials are during calcination, the more complete is the extraction.

The foregoing experiment was performed with one fourth part of salt to one of fresh ore. The result having been satisfactory,

the following mixture containing only one fifth part of salt was calcined :

2000 grains residue of 1·1 per cent	=	22 grains copper.
1000 " fresh ore of 8·6 "	=	86 "
200 " salt.....		

3200 grains containing.....108 grains copper.

This experiment was made with the same care as the others, and with as little stirring as possible. The result weighed 3250 grains, and contained

2·33 per cent. soluble in water	=	76·7 grains copper.
·44 " " in dilute acid	=	14·3 "
Unaccounted for	=	17·0 "

108·0

Since therefore only 71 per cent of the copper was extracted, it follows that one fourth of salt is the minimum quantity which can be used, and at the same time a complete extraction accomplished.

I here closed this series of experiments, having obtained all the definite results sought for. It appears certain that 95 per cent of the copper contained in an ore such as that produced by the Capel mine can be extracted in the humid way by calcining it with twice its weight of impure iron oxide (perhaps less would be sufficient), and one fourth of its weight of salt; provided always that the operation is performed at a very low temperature, that it is not continued beyond a certain point, and that while it is going on the materials are stirred as little as possible. Whether equally good results can be obtained in practically applying this process, is a matter which can only be decided by experience; but there appears to be no reason for doubting that it would be completely successful on the large scale.

REVIEW.

GEOLOGY OF NEW BRUNSWICK.*

It would appear from these reports that two surveys of the Province of New Brunswick proceeded simultaneously, in the summer of 1864; the one under Prof. Bailey being limited to Southern New Brunswick, the other, under Prof. Hind, embracing a general reconnoissance of the whole Province. It results from this that some of the same subjects are discussed in both reports, which must have occasioned some loss of time to the observer, as it does to the reader. On the other hand the people of New Brunswick have an opportunity of comparing the work of their own geologists, Bailey, Matthew, and Hartt, with that of a naturalist of some experience and of large and varied information.

Without any invidious comparison, we may say that Prof. Bailey's Report is distinguished for clearness, systematic arrangement, and careful attention to details; and that its execution must have involved a large amount of laborious field-work. Prof. Hind's is more discursive and popular in style, and in a less amount of local facts brings to bear a great mass of varied information derived from many sources.

Passing by facts relating to economic geology, of which many of great importance to New Brunswick are contained in these reports, we may notice some points of interest in scientific Geology.

Prof. Hind thus describes the occurrence of the "Quebec Group" of rocks in New Brunswick:—

"The supposed northern boundary of this formation within the limits of the Province, commences near the Medisco River on the Bay de Chaleur. The strike of the rocks would carry them to Ramsay's Brook on the Upsalquitch, and thence towards the headwaters of the Tobique to the north of Nictau Lake.

"A few miles from the mouth of the Tobique there are a series

* 1. Observations on the Geology of Southern New Brunswick, made principally by Professor D. W. Bailey, Messrs. George F. Matthew, and C. F. Hartt; prepared and arranged, with a Geological map, by L. W. Bailey, A.M., &c., &c. Pp. 158.

2. A Preliminary Report on the Geology of New Brunswick, together with a special Report on the Distribution of the Quebec Group in the Province; by Henry Youle Hind, M.A., F.R.G.S., &c. Pp. 293.

of silicious slates which appear to underlie unconformably a series of Upper Silurian argillites, green, red, and blue-black, and holding *Favosites Gothlandica*. The strike of these silicious slates would carry them to the north of Nictau Lake, and this line prolonged in a southwesterly direction is supposed to form a rude but continuous curve, which may provisionally represent the northern boundary of the Quebec Group, which has been brought to the surface simultaneously with the granite axis of Devonian age described in Chapter II.

“The continuation of this boundary takes a southerly course and is supposed to cross the Shiktehawk about $3\frac{1}{2}$ miles from its mouth, where a conglomerate occurs, described in Chapter VI. It crosses the Saint John below Presquile, and taking a southwesterly course it enters the State of Maine near the forks of the Meduxnekeag, pursuing its course towards the Atlantic Ocean on the north flank of the granitic axis, where it is represented on Mr. C. H. Hitchcock's Map of Maine as a belt of mica schist. On the south-east side of this axis the Quebec Group is again brought to the surface, its eastern boundary being in great measure covered up by the Bonaventure formation or base of the carboniferous series, which in many places reposes upon it horizontally or nearly so. Until further investigations establish the contrary, all the sedimentary rocks, with the exception of the carboniferous, north of the granitic axis, which comes in from the State of Maine at Saint Stephens, and proceeds in an easterly direction through Queen's County to and beyond the Saint John, may be considered as belonging to this group, although it is not improbable that there is a narrow belt of middle silurian rocks, on the north-east flank of the carboniferous series a few miles due west of Fredericton. The rocks on the north side of this last-named axis, described by Hitchcock as mica schist, in its prolongation through Maine to the Atlantic Ocean, most probably belong to the Quebec Group.

“The breadth of this group of rocks measured at right angles to the strike within the limits of the boundaries just described, will be approximately as follows, after deducting the granite axis :

1. Five miles from Bathurst,	....	....	....	20 miles.
2. From Ramsay's Brook, southeasterly,	....	....	....	36 “
3. From near the Nictau	“	....	....	44 “
4. From the Tobique,	“	....	....	43 “
5. From the Maduxnekeag,	“	....	....	38 “
6. On the New Brunswick and Canada R. R.,	....	....	....	25 “

"It has been already stated that this granite axis (Chap. II) is really composed of numerous narrow belts, which come up between the schists of the Quebec Group, also that it has a much more northerly extension than represented by Dr. Gesner. On the South-west Miramichi, there are no less than ten distinctly parallel granite belts, with belts of slate and schist between them. It is clear that this arrangement of the granite and slates may exercise a very important influence upon the rocks now under review, as it not only extends the area over which they may be found, but the metamorphic action exhibited by the granite may have effected a material change in the composition and crystalline arrangement of some of the strata."

DEVONIAN INSECTS.

A very striking new fact in Prof. Bailey's Report is the discovery of insects in the Devonian of St. Johns by Mr. Hartt,—the first instance on record of insects so old. These remains are thus described by Mr. Scudder in a letter to Mr. Hartt:—

Boston Society of Natural History,

January 11, 1865.

"MY DEAR MR. HARTT,—I have made as careful an examination as my present circumstances will permit, of your most interesting collection of the fossil remain of insect-wings from Lancaster. There are ten specimens in all, eight of which are reverses of one another, thus reducing the number to six individuals; of these, one, a mere fragment, belongs, I think, to the same species as another, of which the most important parts of the wing are preserved, so that we have five species represented among these Devonian Insects, and these remains are all, I suspect, composed of portions of the anterior wing alone. The data being thus fragmentary, the conclusions cannot be quite so satisfactorily determined as we could wish, but we can still discover enough to prove that they are of unwonted interest. Besides the peculiar interest which attaches to them as the *earliest known traces of insect life on the globe*, there is very much in themselves to attract and merit our closest attention.

"One of them is a gigantic representative of the family of *Ephemerina* among Neuroptera, some three or four times the size of the largest species now living, with which I am acquainted.

"Another borrows some striking points of the peculiar wing-structure

ture of the Neuropterous family *Odonata*, and combine with them those of families remote from that, and even belonging to a distinct section of the Neuroptera, exhibiting to our view a synthetic type which combines in one the Pseudoneuroptera and the Neuroptera, and represents a family distinct from any hitherto known.

“Other fossil insects, found in carboniferous concretions in Illinois and described in Silliman’s Journal (N. S. xxxvii, 34), which Professor Dana has kindly allowed me to examine,* also belong to hitherto unrecognized families, exhibiting similar relations to these in-our-day-disconnected Sections of Neuropterous insects; and your third species is a member of still another family of Neuroptera, which finds its natural relations between the two described by Professor Dana.

“A fourth, of which only an important fragment was found, would seem to belong to the Neuroptera, but by some peculiarities of the minuter cross-veins, thrown off in the middle of the outer edge of the wing, in a most irregular and unusual manner, suggests no intimate relations with any known family, but must have belonged to a group of large and weak-winged insects.

“The fifth and last to be mentioned is of very striking interest, because, while it exhibits the peculiar venation which forms the well-known tympanum or stridulating apparatus of the male, in the Orthopterous *Locustariae* (though differing somewhat from that), it also most resembles the Neuroptera in all or nearly all the other peculiarities of its structure, and suggests the presence in the insect-faunæ of those ancient times of a synthetic type, which united the characteristics of the Orthoptera and Neuroptera, in themselves closely allied; this point, however, requires patient and severe investigation, and only my earliest impressions are here recorded, made, however, immediately after a close examination into the relations of other fossil insects.

“I earnestly hope that this locality, from which these remains were disinterred, may receive a most careful and thorough examination by yourself, who have already shown so much diligence and careful scrutiny in the discovery of such important and easily overlooked remains. Hitherto, the study of fossil insects has been mainly confined to those of much more recent date, and has resulted in shedding comparatively little light upon geological and palæontological questions; but these few remains, coupled with the pair of insects found in Illinois, induce us ardently to anticipate that the future study of fossil insects, drawn from such ancient

strata as these, may lead to as brilliant and important results, in the elucidation of geological problems still open, in widening the range of our palæontological horizon, and in our general knowledge of the history of Life on our globe in all its bearings, as have been reached by the study of the remains of animals of a more substantial structure, but which have hitherto been denied to the student of fossil Entomology."

The following, from Prof. Hind's Report, on glacial striation in New Brunswick, is also of interest, even to those who prefer icebergs to glaciers as a means of effecting such striation.

ACTION OF GLACIAL ICE.

"Whenever the loose covering of clay and sand is swept off the solid rock throughout the whole extent of this Province, glacial striæ are visible; in other words, the rocks are seen to be polished, striated and sometimes deeply grooved. These striations are observed at all altitudes, but they have been obliterated over wide areas by atmospheric influences. During the past summer I saw them on the summit of Blue Mountain, 1650 feet above the sea. There small surfaces of a very hard metamorphised conglomerate are beautifully polished and striated. They abound throughout the slate region of the Province, the slate receiving with ease and retaining with much persistency the markings produced by the slowly moving glacial mass.

"The general direction of these striæ is N. 10° W.; but there are often two sets to be seen, differing in direction by two or three degrees. The best place within a few miles of Fredericton for examining these striæ under very singular circumstances, is in Prince William Parish, at and near the antimony mines. On the road to the mines leading from the main post road the striæ are beautifully retained on the polished surface of a hard silicious slate. The country in that vicinity has been ground away and removed by ice to a vertical depth of some hundred feet, as has, indeed, a considerable portion of, if not the whole, of the Province.

"In Prince William, however, an observer can not only see the 'tracks' of the glacial mass graven on the rocks, but he can also see the work it has accomplished in excavating Lake George. He can trace the course of the glaciers far beyond Lake George (442 feet above tide) and Bear Lake; see it in imagination sweeping past the edge of the Plateau of the Carboniferous series, which t

has worn away to an escarpment west of Oromocto Lake, and as a glacial stream passing down the valley of the Magaguadavic to the sea.

“ The western extremity of the Coal Measures holds up Lake Oromocto. It has been denuded away by lateral glacial action towards the west, until we have the remarkable spectacle presented of a bold escarpment facing the west, holding up a Lake containing 10,000 acres, and 115 feet above the valley it overlooks. Lake Oromocto is 370 feet above the sea, the scarpment which overlooks the Magaguadavic is 394 feet, and the river itself flowing at the base of the escarpment is 256 feet above the same level.”

GENERAL DIRECTION OF THE ICE-FLOW IN NEW BRUNSWICK.

The polishing of some of the harder rocks is extremely beautiful, and shows that the action of the ice slowly moving over it must have continued for an exceedingly long period of time. It is not to be supposed that the ice had uniformly one direction: on the contrary, its direction may have varied through an entire quadrant under different conditions. When we look at glacial striæ we see only the last record of the moving mass, the last impression of its presence; but in what direction it moved, or with what effect at any period before the graving of its last striations, we can only conjecture.

An inspection of the preceding table, although it is very imperfect, will show that the direction of the moving mass of ice was generally nearly due north and south. As the glaciers approached the sea they accommodated themselves to the sinuosities of the valleys through which they made their escape, and produced striations in different directions. At a greater elevation and more inland, what were on the sea-shore mere ice-streams, would be in the interior a uniform or broad glacial mass. Suppose for instance that a mass of ice several hundred feet thick, like that which now covers in part the surface of Greenland,* once extended over the

* “ To have a correct idea of the glacier accumulation in Greenland, we must imagine a narrow continent of ice flanked on its seaward sides by a number of Islands, and in every other direction lost to vision in one continuous and boundless plain. Through the spaces between these apparent Islands, the enormous glacial accumulations lowly seek their passage to the sea, and send off an annual tribute to encumber, to cool, and to dilute the waters of the adjoining ocean. The average height or depth of the ice at its free edge in these intervals or valleys between the

entire surface and flanks of the granitic highland range to the north and northeast of the Saint John. During its slow movement tow-

IN THE FOLLOWING TABLE ARE GIVEN THE DIRECTION AND LOCALITY OF SOME OF THESE GLACIAL STRIÆ.

*Table showing the Direction of Glacial Striæ in New Brunswick.**

No.	Kind of Rock.	Locality.	Height above the Sea.	Direction.
1	Grey Grist,	Fredericton,	About 350 feet,	N. 10° W.
2	Silicious Slate,	Prince William,	" 400 "	N. and S.
3	Grey Grits,	Four miles on Mira-		
		michi Road,		N. 10° W.
4	" "	Hanwell Road,†	" 400 "	N. 10° W.
5	" "	Maryland Road,	" 400 "	N. 10° W.
6	" "	" "	" 400 "	N. 10° W.
7	Red Sandstone,	" "	" 400 "	N. 10° W.
8	Greenstone,	Gagetown Road,		N. and S.
9	Conglomerate,	Near mouth of Kes-		
		wick,		N. N. W.
10	Reddish Conglo-	Near Gagetown,		N. 22° W.
	merate,	Oromocto Lake	" 370 "	N. N. W.
11	Conglomerate,	Harvey Settlement,		N. and S.
12	"	9 miles south of		
13	Red Sandstone,	Saint Andrews,	" 60 "	W. by W.
14		Chamcook Lake		N. N. W.
		Shore,		
15		On high land near		N. by W.
		St. Andrews.		N. 45° W.
16	Trap,	L'Etang,	" 100 "	N. W.
17	"	Magaguadavic Falls		
18	Granite,	East of Musquash		N. 20° E.
		Valley,		
19	Slates,	Near Penitentiary,		N. 30° E.
		Saint John,		N. 25° E.
20	Syenite,	South Bay,		N. W.
21	"	Mouth of Nerepis,		N. N. W.
22	"	Oxbow of "		
23	Grey Grits,	Old Woodstock		N. 10° W.
		Road,		N. 10° W.
24	Slates,	Spring Hill,		
25	Purple Sand-			N. 10° W.
	stones,	Gonish Road,		
26	Metamorphosed			
	Conglomerate,	Blue Mountain,	" 1650 "	N. and S.
27	Grits,	Opposite Frederic-	" 350 "	N. 10° W.
		ton,		

projecting points of coast is 1200 or 1500 feet, of which about one eighth or 150 feet will be above the water. In some of the valleys, however, the depth is upwards of 2400 feet. These phenomena can be seen at the

* Some of these observations were recorded by the late Dr. Robb.

† Between Fredericton and Hanwell, very numerous and uniformly. N. 10° W.

ards the sea it would not only bring with it the materials it tore off the rocks over which it was passing, but it would also score and polish the rocks themselves. At that period the valley of the Saint John was probably, but not necessarily, filled with drift. The glacial mass passed over it towards the sea, scratching and polishing the rocks during its slow but irresistible journey. Approaching the sea it would probably split into tongues, chiefly on account of its moving eccentrically, and thus covering a larger area owing to the figure of the earth; and by reason of climate these tongues would reach the sea as ice rivers, in process of time excavating for themselves deeper channels, which ultimately became 'Fiords' or deep bays where the glaciers 'calved,' to use the term commonly employed in Greenland, and gave off their icebergs. An inland glacier having, as it were, once established itself in any determinate geographical position, would, in process of time, assisted by its own glacial river, wear out a lake-basin.*

Prof. Bailey and Mr. Matthew have worked out with much labor and success the complicated geology of the rocks in the vicinity of St. John, and have ascertained the fact that these include representatives of the Lowest Silurian beds, and probably of the Laurentian and Huronian. We shall give in our next number their account of the oldest fauna found in that neighborhood.

MISCELLANEOUS.

A NEW AMERICAN SILKWORM.—After numerous experiments, Mr. L. Trouvelot, of Medford, Mass., U.S., has succeeded in rearing successfully, and in great numbers, *Attacus Polyphemus*, Linn., and in preparing from its cocoon an excellent quality of silk, possessing

present day in Baffin's Bay and Davis' Straits." "As we advance northwards along the coast of west Greenland, and thus diminish the annual mean temperature both of the sea and of the atmosphere, we find the glacier approaches nearer and nearer the coast line, until in Melville Bay, latitude 75°, it presents to the sea one continuous wall of ice, unbroken by land, for a space of probably seventy or eighty miles.—Dr. Sutherland, *on the Geological and Glacial Phenomena of the Coasts of Davis' Straits and Baffin's Bay*.—Proceedings of the Geological Society, 1853.

* See Professor Ramsay's paper "On the Glacial Origin of Lakes".—Journal of the Geological Society, August, 1862.

great lustre and strength, and pronounced superior to Japanese and all other silks, except the best Chinese, by competent judges.

The silk is unwound by a simple process perfected by Mr. Trouvelot, each cocoon yielding about 1500 yards. This insect is very hardy, being found throughout the Northern States and Canada; and, as it feeds upon the leaves of oak, maple, willow, and other common forest trees, may be reared easily in any part of the country.

Mr. Trouvelot has gradually increased his stock from year to year, by raising young from the eggs of the few individuals first captured, until he has at present seven waggon-loads of cocoons, the entire progeny of which he proposes to raise during the coming season.

The thanks of the country are due to the ingenious and persevering author of this successful attempt to introduce a new and interesting field for industry and enterprise, which cannot fail to be a source of profit to these who intelligently engage in it, and of increased wealth and prosperity to the people, should it be developed to the extent that now seems possible.

The first public notice of his experiments with this insect was given by Mr. Trouvelot at a meeting of the Institute of Technology, at Boston, about a year ago, when he exhibited specimens of silk manufactured from it, both natural-colored and dyed.—*A. E. V. in Silliman's Journal.*

BOTANICAL NOTES.—*Aspidium fragrans* Swartz. Our correspondent, Dr. Thomas, has had the good fortune to find this rare fern at Rivière-du-Loup (en bas); its only other Canadian locality certainly known to me is "East shore of Lake Superior in rocky open woods," where it was found by Mr. Barnston in 1859. *Asplenium viride* Hudson, has also been found by Dr. Thomas at the same place; the provincial range of this fern would thus appear to be from Canada East and New Brunswick (Mr. Matthew) to Newfoundland,

Our correspondent, Mr. Macoun, has found *Myosurus minimus* Linn., near Belleville—a very interesting discovery: he also announces *Potamogeton abrotus* Wood, and *Cardamine hirsuta* var. *Virginica* as natives of that neighborhood. W.

THE
CANADIAN NATURALIST.

SECOND SERIES.

ON THE EXTRACTION OF COPPER FROM ITS ORES
IN THE HUMID WAY.

By THOMAS MACFARLANE.

PART II.—*Being a continuation from page 231.*

In adverting to the best method of putting this process in practise, it may be well first to take into consideration the best means of reducing the ore to powder. With such an ore as that of the Capel mine, it will probably be found, that, after it has passed through the operation of coarse spalling (by which it is reduced to pieces of about six inches in diameter), it cannot be further concentrated by fine spalling and picking, without the loss of much of the copper contained in the ore. (The waste from the fine spalling operation at Capel mine contained 3.4 per cent copper.) According to experience gained at the Acton mine, lime-rock after coarse spalling, can be reduced to pieces of $6\frac{1}{2}$ inches in diameter (mixed with much smaller pieces and dust) for 10 cents per ton of 2000 lbs., by means of Blake's stone breaker, that machine reducing sixty tons of such rock in ten hours. The only crusher which can at all compare with Blake's is that patented by J. J. Storer and J. D. Whelpley of Boston, which breaks the rock so as to go through holes of from three-fourths to one inch square; but it must be broken to a size of from three to four inches in diameter before it is introduced into the crusher. It may therefore reasonably be compared with Blake's. According to the inventors, Whelpley and Storer's crusher will break up eight tons of ordinary quartz

per hour. The cost of feeding and attending the mill, and removing the product, together with expenses of engine and fuel, would probably amount to \$6.50 per day, or $8\frac{1}{4}$ cents per ton. The cost of Whelpley and Storer's machine is somewhat more than that of Blake's, and while nine horse-power only is required for the latter, fifteen is said to be necessary for the former. With these data it may therefore be safe to estimate that the preliminary crushing of the ore would cost 10 cts. per ton. The crushing by means of ordinary rollers is here left out of consideration, as the ore must be very much reduced in size (to two inches in diameter and less) before it is possible to treat it by means of rollers.

In reducing the ore to a finer powder than is possible by means of any crusher, the choice lies between millstones, stamps, and Whelpley and Storer's pulveriser. The operation of pulverising by means of the first named is too expensive; and wet stamps, although they do it cheaper, have this disadvantage that the drying of the fine powder and the subsequent crushing of such parts of it as might cake together would increase the cost materially. By far the best pulveriser is undoubtedly that of Whelpley and Storer, which with twelve horse-power reduces to a state of fine dust from 1500 to 2000 lbs. of ordinary quartz or other stone per hour. Assuming that this machine were driven by the same engine which works the crusher, the cost of pulverising could not exceed 20 cents per ton.

The pulverised ore, after having been mixed with the salt and iron oxide, is next calcined; and it would seem quite practicable to effect this calcination in a semi-reverberatory furnace, the hearth of which would consist of cast-iron plates heated by the flame from a furnace passing through flues beneath. The smoke, etc., from the fire would be kept altogether, distinct from the gases evolved by the ore and other ingredients during the calcination. Since diligent stirring is rather injurious than otherwise, it follows that no great amount of labor is necessary; and since the temperature is to be kept as low as possible, it is also evident that the expenditure of fuel will be inconsiderable. It is therefore probably a reasonable estimate that \$1 per ton would cover the expense of calcination.

The gases evolved during this operation are sulphurous acid and chlorine in very nearly the proportions of their equivalents. Partly to create a draft through the furnace and partly in order to utilise these gases, it would be well to put into connection with

the furnace a spray-wheel and chamber such as described by Whelpley and Storer as being attached to their pulveriser. In contact with the water, these gases would form dilute sulphuric and hydrochloric acids, the further treatment and separation of which would be matters of comparative ease.

The best method of treating the solution obtained by lixiviating the calcined product would probably be simply to acidify the solution slightly, and precipitate while warm with metallic iron. The resulting copper would, after washing, be almost chemically pure; and in all likelihood, by compressing it into cakes and fusing it in crucibles, a pure product might be obtained. The residual solution after the precipitation would, on evaporation, yield large quantities of sulphate of soda. The cost of the manipulation connected with the lixiviation, etc., would probably not be less than \$1.50 per ton; and if we include the production of the sulphate of soda, it would probably be raised to \$2.50 per ton.

Although it is altogether impossible to give any reliable estimates with regard to the cost of a process which has not been tried on a large scale, yet it may be as well to attempt a calculation as to the cost and proceeds of this method of extraction, in order to ascertain as to whether it is economically feasible. The expenditure on the operation might be estimated as follows:

One ton of 7 per cent ore (\$2.25 per unit on 6½ per cent).	\$14 62
Crushing.	0 10
Pulverising.	0 20
Calcining.	1 00
Lixiviating, &c.	2 50
Refining the precipitated copper to ingot.	2 00
Concentrating the sulphuric and muriatic acids.	3 00
500 lbs. salt.	2 00
130 lbs. iron.	6 00
	<hr/>
	\$31.42

The following sums might be realized for the various products:

130 lbs. ingot copper (supposing 6 per cent only to be obtained from 7 per cent ore), at 22 cents.	\$26 40
979 lbs. dry sulphate of soda (supposing only one third of the sulphur to be recoverable in this form), at 1 cent per lb. (6s. sterling is its value in England)	9 79
660 lbs. sulphuric acid (supposing another third to be recoverable in this form), at 2 cent. per lb. (1 penny per lb. being its value in England)	13 20
1188 lbs. muriatic acid, at 2 cents.	5 94
	<hr/>
	\$55 33

According to these figures, a profit of \$23.91 might be made on every ton of the ore treated. There may of course be many errors in these estimates, but they would seem at least to justify a considerable expenditure in order to ascertain whether the process can be worked on the manufacturing scale with success and profit.

Acton Vale, C. E., 16th June 1865.

SYNOPSIS OF THE FISHES OF THE GULF OF ST. LAWRENCE AND BAY OF FUNDY.

By PROF. THEODORE GILL, M.A.

The interest that has for some time been manifested in the fishes and fisheries of the Gulf of St. Lawrence and Bay of Fundy, and the absence of facilities for the ready identification of some of the species, appear to render desirable the publication, in a brief and connected form, of the views respecting the nomenclature and affinities of the species, resulting from our present knowledge of the class. This is the more desirable, as some of the observations hitherto made—on account of the difficulty experienced in identifying the species—have not that full value to which the conscientious care with which they have been made should entitle them. The present enumeration is based on the observations of Messrs Richardson, H. R. Storer, Dawson, Jones, Perley, Fortin, and Bell, verified in most cases by an examination of specimens either from the district referred to, or from closely contiguous portions of the same faunal region.

In the enumeration of the species, I have essentially followed the order adopted in the 'Catalogue of the Fishes of the Eastern Coast of North America,' modified however in some important respects by subsequent studies. Still further departures should be made,—but I defer such changes till the publication of a more extensive work on which I am now engaged. The analytical tables, artificial as such are, will, it is hoped, prove useful in assisting in the progressive identification of unknown forms, as well as in conveying information concerning the technical or natural characters of the groups, and in many cases their relations to each other. How difficult the compilation of such tables is can be readily appreciated by experienced ichthyologists who will examine any of those hitherto published. I may not therefore possibly hope that the present attempt should be exempt from many defects: only the more obvious superficial characters of

families peculiar to the types here noticed, but not to all belonging to them, have in several cases been employed. In conclusion, it need only be stated that the nomenclature here adopted is in every case in most strict conformity with the rules proposed by the British Association, founded on the teachings of the great Swedish reformer, and subsequently endorsed by the American Association.* We may regret that rules so truly founded on good sense should have been so frequently infringed in previous enumerations of our fishes, and that the consequent innovations should have been admitted unchallenged by so many responsible naturalists. Many of these corrections, so long deferred, have only been very recently made, and such are adopted in the following enumeration. It is to be hoped, as it is believed, that the time has passed when obvious infractions of wholesome rules of nomenclature should not only be committed with impunity, but even sustained by others.

Those species which have not been found in the gulf or bay, but in closely contiguous waters, or at places beyond both extremities of the area indicated, are pointed out by an asterisk (*) placed before the name: when the name or specific rank is doubtful, an asterisk is generally placed after it.

SUB-CLASSES OF FISHES.

- I. Branchiæ free at their distal margins.
 - A. Optic nerves decussating. Arterial bulb normally with two opposite valves at its origin. (Skeleton more or less completely ossified.) TELEOSTEI.
 - B. Optic nerves not decussating. Arterial bulb with several rows of valves. (Skeleton variable.) GANOIDEI.
- II. Branchiæ attached. (Skeleton always cartilaginous.)
 - A. Optic nerves not decussating. Arterial bulb with several rows of valves. Ventral fins always present, abdominal, provided in the males with peculiar sexual appendages. *Copula gaudent.* ELASMOBRANCHIA.
 - B. Optic nerves decussating. Heart without muscular tunic, but with two opposite valves. Ventral fins entirely absent. (Body serpentiform, without pectorals or ventrals.) MARSIPOBRANCHIA.

* In order not to be misunderstood, I may state that, like most others, I have not hitherto followed § 2 of the British rules limiting priority to the twelfth edition of the *Systema Naturæ*; but at the same time I believe that if the tenth edition were substituted for the twelfth, adherence to that rule might not be unadvisable. No cause for the infraction of the rule occurs in the present article.

TELEOSTEI.

ORDERS AND SUB-ORDERS.

I. Branchial laminae pectinated.

1. Maxillaries normally developed and normally distinct from each other.

A. Pubic bones generally connected with scapular arch. Ventral fins anterior (thoracic to jugular).

B. Sides symmetrical.

C. Dorsal rays anteriorly articulated, spinous; first ventral ray also spinous.

α. Branchial apertures in advance of the pectoral fins.

β. Branchial apertures behind or in the axils of the pectoral fins.

CC. Dorsal rays articulated as well as the first ventral ones.

BB. Sides dissimilar, both eyes being situated on one side, which is darker than the eyeless one.

AA. Pubic bones free; ventral fins abdominal.

B¹. Pharyngeal bones more or less plane.

B². Pharyngeal bones falciform.

2. Maxillaries generally obsolete or rudimentary. *Scapular arch not connected with skull.* Body serpentiform. APODES.

3. Supramaxillary bones rudimentary, enveloped in more or less extended barbels.

4. Elements of lower jaw united and forming a single piece.

II. Branchiae tufted. (Body enclosed in a case formed by regular plates.)

A. Breast with no suctorial disk.

B. Cheeks not defended, no suborbital bone forming a stay. Posterior dorsal rays branched.

The area in front of pectoral fins much abbreviated, very much higher than wide.

1. Jaws normal, more or less protractile.

α. Spinous dorsal normally longer than soft portion.

TELEOCEPHALI.

ACANTHOPTERYGII.

PEDICULATI.

JUGULARES.

HETEROSOMATA.

ABDOMINALES.

EVENTOGNATHI.

NEMATOGNATHI.

PLECTOGNATHI.

SCLERODERMI.

LOPHOBANCHII.

FAMILIES OF ACANTHOPTERYGII.

- * Spinous dorsal not depressible in a furrow. Lower pharyngeal bones separated. PERCIDÆ.
 ** Spinous dorsal depressible in a furrow. Lower pharyngeal bones separated. (*Lepominae*.) CENTRARCHIDÆ.
 * Spinous dorsal depressible in a furrow. Lower pharyngeal bones united. LABRIDÆ.
 β. Spinous dorsal shorter than second.
 * Skull with cavernous or excavated bones. Caudal with the lateral line continued between its median rays. SCLERIDÆ.
 ** Skull smooth, not excavated. POMATOIDÆ.
 2. Jaws normal, not protractile, the upper being covered by the skin at symphysis. Body elongated more or less fusiform. Last soft dorsal rays generally detached, and developed as spurious finlets. SCOMBRIDÆ.
 3. Jaws pointed, the upper united and prolonged into an ensiform weapon. XIPHIIDÆ.
 B². Cheeks partly protected. Area in front of pectoral fins well developed, oblong! Ventral fins considerably behind pectorals, with large spines. GASTEROSTEIDÆ.
 B³. Cheeks defended by one of the suborbital bones, which extends to the inner ridge of the operculum. SCORPAENIDÆ.
 D¹. First dorsal longer than the second.
 D². First dorsal shorter than the second.
 α. Ventral fins approximated, generally imperfect.
 1. Body not mailed.
 2. Body completely encased by plates.
 β. Ventral fins distant, separated by a wide flattened area.
 B⁴. Cheeks unarmed, the suborbital osselets being little developed. Dorsal entirely composed of spines.
 α. Pyloric coeca obsolete.
 1. Teeth enlarged, adapted for crushing.
 2. Teeth small and acute.
 β. Pyloric coeca developed.
 1. Ventral fins developed. Head conic in front, compressed.
 2. Ventral fins obsolete. Head oblong, pitted above oral; cleft subvertical.
 A.A. Breast with suctorial disk formed by the perfect union of the ventral fins. STICHAIDÆ.
 CRYPTACANTHIDÆ.
 CYCLOPTERIDÆ.

TELEOSTEI.

Order TELEOCEPHALI.

Sub-order ACANTHOPTERYGII.

PERCIDÆ GILL.

PERCINÆ (Bon.) Gill.

Anal fin with two spines. Vertebrae in increased numbers ($10 + x \mid 14 + y$).

Genus *Perca* Linn.

Teeth villiform. Dorsal fins distinct. D. xiii – xv. i – ii. 13 – 14. A. ii. 6 – 9.

Perca flavescens Mitch. Yellow perch; Perch. (Perley.)

Perca flavescens, Storer, Mem. Am. Ac. v, 52, pl. ii, fig. 1.

LABRACINÆ Gill.

Anal fin with three spines. Vertebrae generally in normal number ($10 - 11 \mid 14 - 15$).

The genera *Roccus* and *Morone* differ even more decidedly in anatomical than external characters.

Genus *Roccus* Gill ex Mitch.

Tongue with teeth at middle. Dorsal fins almost distinct. D. ix. i. 12 – 14. A. iii. 10 – 13.

Roccus lineatus Gill. Striped bass. (Perley.)

Labrax lineatus, (C.), Storer, Mem. Am. Ac. v, 54, pl. i, fig. 4.

Genus *Morone* Gill ex Mitch.

Tongue with no teeth in middle. Dorsal fins connected at base. D. ix. i. 12 – 14. A. iii. 7 – 11.

Morone Americana Gill. White perch. (Perley.)

Labrax rufus, Storer, Mem. Am. Ac. v, 57, pl. i, fig. 1.

CENTRARCHIDÆ GILL.

LEPOMINÆ Gill.

Soft parts of dorsal and anal fins equal and opposite to each other.

Genus *Pomotis* (Raf.) Gill.

D. x 10–12. A. iii. 10–12. Pharyngeal bones closely contiguous, with paved teeth.

Pomotis aureus Gill ex Walb. Sun-fish. (Perley.)

Pomotis vulgaris, Storer, Mem. Am. Ac. v, 60, pl. iii, fig. 1.

LABRIDÆ (Cuv.) BLKR.

LABRINÆ (Bon.) Gthr.

D. xiii — xiii + x. Teeth conical. Lateral line continuous, not abruptly decurved behind.

Genus *Tautoga* (Mitch.) Gthr.

Opercles naked. Teeth in two rows. D. xvii. — 10. A. iii 7 — 8.

Tautoga onitis Gthr. ex Linn. Black-fish. (Perley.)

Tautoga Americana, Storer, Mem. Am. Ac. v, 276, pl. xx, fig. 2.

Genus *Tautogolabrus* Gthr.

Opercles (including interopercle) scaly. Teeth in a band. D. xvii — xix. 9 — 11. A. iii, 8 — 9.

Tautogolabrus adpersus Gill ex Walb. Cunner. (Perley.)

Ctenolabrus coeruleus, Storer, Mem. Am. Ac. v, 274, pl. xx, fig. 1.

SCIAENIDÆ (Cuv.) GTHR.

OTOLITHINÆ Gill.

Body fusiform. Lower jaw projecting. Vertebrae about 14 + 10.

Genus *Cynoscion* Gill.

Cynoscion regalis Gill ex Schn. Weak-fish.

Otolithus regalis, Storer, Mem. Am. Ac. v, 122, pl. ix, fig. 1.

POMATOMIDÆ GILL.

POMATOMINÆ Gill.

Teeth compressed. Anal fin moderate.

Genus *Pomatomus* Lac.

Pomatomus saltatrix Gill ex Linn. Blue-fish.

Temnodon saltator, Storer, Mem. Am. Ac.

SCOMBRIDÆ (Cuv.) GILL.

SCOMBRINÆ (Bon.) Gill.

Dorsal fins distant. Tail with cutaneous keels.

Genus *Scomber* (L.) Cuv.

Body slender, with no enlarged scales in front. Finlets 5 — 6.

Scomber grex Mitch., 1814. Mackerel.

Scomber vernalis, Storer, Mem. Am. Ac. v, 132, pl. xi, fig. 2.

ORCYNINÆ Gill.

Dorsal fins generally approximated. Tail with cutaneous keels.

Genus *Orcynus* (Cuv.) Gill.

Lateral line simple. Vomer and palatines as well as jaws, with small teeth. D. xii — xv.

Orcynus secundo-dorsalis Gill ex Storer. Horse-mackerel; Albicore. (Perley.)

Thynnus secundo-dorsalis, Storer, Mem. Am. Ac. v, 143, pl. xii.

XIPHIIDÆ Bon.

XIPHIINÆ (Bon.) Gill.

Ventral fins obsolete.

Genus *Xiphias* (L.) Cuv.

Tail with a single cutaneous keel. Dorsal fin in young, entire behind; in adult, with the greater portion of the spinous part obsolete.

Xiphias gladius Linn.† Sword-fish. (Perley.)

Xiphias gladius, Storer, Mem. Am. Ac. v, 149, pl. xiii, fig. 2.

GASTEROSTEIDÆ Bon.

GASTEROSTEINÆ (Bon.) Brevoort.

Body more or less fusiform. Head conic or sub-conic.

Genus *Gasterosteus* (L.) Brev.

Body stout, fusiform. Free dorsal spines 2 — 3.

Gasterosteus biaculeatus (Shaw) Mit.* Stickleback. (Perley.)

The species of this genus require a thorough re-examination.

Genus *Pygosteus* Brevoort.

Body elongated, sub-fusiform. Free dorsal spines 6 — 10.

Pygosteus occidentalis Brev. ex Cuv.*

Pygosteus Dekayi Brev. ex Ag.*

These species likewise require confirmation.

SCORPÆNIDÆ (Sw.) GILL.

SCORPÆNINÆ (Bon.) Gill.

D. xi — xv. Spinous and soft dorsals connected.

† On the point of sending this for publication, I received from Mr. Jones of Halifax, a figure of two caudal vertebræ of this species obtained while dredging in the harbor of Halifax.

Genus *Sebastes* Cuv.

D. xiv + i. 13. — 15. A. iii. 6 — 8. Vertebrae in increased number. (c. 12 + 19).

Sebastes norvegicus Cuv.*

Sebastes norvegicus, Cuv. et Val., Nat. Hist. des Pois., iv, 327, pl. 87.

Sebastes viviparus Kroyer. Rose-fish; Red sea-perch; Snapper. (Perley.)

Sebastes norvegicus, Storer, Mem. Am. Ac. v, 86, pl. vii, fig. 1.

HEMITRIPTERINÆ GILL.

D. xv + x. Spinous and soft dorsals separated.

HEMITRIPTERUS Cuv.

Hemitripterus Acadianus Storer ex Walb.

Hemitripterus Acadianus, Storer, Mem. Am. Ac. v, 83, pl. vii, fig. 4.

COTTIDÆ (Rich.) GILL.

COTTINÆ (Bon.) Gill.

Head large. First dorsal moderate, generally oblong, mostly behind head.

Genus *Cottus* Linn.

Branchial membrane partly free below. D. viii — x | 13 — 17. Teeth on vomer.

Cottus grenlandicus Cuv. Sculpin; Bull-head. (Perley.)

Acanthocottus variabilis, Storer, Mem. Am. Ac. v, 74, pl. iv, fig. 1.

Pre-opercular spines 3; the upper not extending as far as the opercular.

Cottus Labradoricus Gthr. ex Grd.

Acanthocottus Labradoricus, Grd., Boston Journ. Nat. Hist.

Pre-opercular spines 4; the upper not extending as far as the opercular.

Cottus octodecim-spinosus Mitch. Sculpin; Bull-head. (Perley.)

Acanthocottus Virginianus, Storer, Mem. Am. Ac. v, 76, pl. iv, fig. 2.

Pre-opercular spines 3; the upper extending beyond the opercular one.

Genus *Gymnacanthus* Sw.

Branchial membrane free below around margin. Vomerine teeth, none. D. ix — x | 13 — 16.

Gymnacanthus patris Gill ex Storer.

Acanthocottus patris, Storer, Boston Journ. Nat. Hist. vi, 250, pl. 7, fig. 2.

AGONIDÆ (Sw.)

ANOPLAGONINÆ Gill.

Spinous dorsal fin obsolete.

Genus *Aspidophoroides* Lac.

Teeth on jaws only.

Aspidophoroides monopterygius Storer, 1839.

Aspidophorus monopterygius, Storer, Mem. Am. Ac. v, 80, pl. 8, fig. 1 (extremely bad).

TRIGLIDÆ (Bon.) BLKR.

DACTYLOPTERINÆ Gill.

Pectoral fins in adult excessively large, divided into an upper small and a lower larger part, and with no inferior thickened free rays.

Genus *Dactylopterus* Lac.

Dactylopterus volitans Lac.

Dactylopterus volitans, Storer, Mem. Am. Ac. v, pl. vi, fig. 5, 6.

XIPHIDIONTIDÆ† GILL.

Body compressed and ribbon-shaped. Dorsal fin nearly uniform, entirely composed of robust spines.

Genus *Muraenoides* Lac.

Branchiostegal membrane free below. Anal fin with two simple spines.

Muraenoides ingens Gill.*

Gunnellus ingens, Storer, Boston Journ. Nat. Hist. vii.

Muraenoides mucronatus Gill.

Gunnellus mucronatus, Storer, Mem. Am. Ac. v, 260, pl. xvii, fig. 2.

ANARRHICADIDÆ GILL.

Genus *Anarrhicas* Linn.

Body robust. Caudal convex free from the dorsal and anal.

Anarrhicas vomerinus Ag.* Wolf-fish; Sea-wolf. (Perley.)

Anarrhicas vomerinus, Storer, Mem. Am. Ac. v, 265, pl. 18, fig. 1.

† The much elongated, ribbon-shaped body, form of head, structure of dorsal and pectoral fins, &c., appear to indicate that the centronotoid blennioids represent a true family.

STICHÆIDÆ GILL.

Genus *Leptoblennius* Gill.

Body very slender, with no lateral line. Teeth only on jaws.

* *Leptoblennius serpentinus* Gill.

Blennius serpentinus, Storer, Mem. Am. Ac. v, 257, pl. 17, fig. 1 (poor).

Genus *Eumesogrammus* Gill.

Body moderately elongated, with the lateral line divided into a superior and larger median branches.

Eumesogrammus sub-bifurcatus Gill.

Pholis sub-bifurcatus, Storer, Mem. Am. Ac. v, 258.

CRYPTACANTHIDÆ GILL.

Genus *Cryptacanthodes* Storer.

Cryptacanthodes maculatus Storer.

Cryptacanthodes maculatus, Storer, Mem. Am. Ac. v, 82, pl. viii, f. 6.

Body and fins ruddy, with dark spots.

Cryptacanthodes inornatus Gill.† Ghost-fish.

Cryptacanthodes inornatus, Gill Proc. Ac. Nat. Sc. Phila., 1863, 332.

Body and fins whitish, immaculate.

CYCLOPTERIDÆ (Bon.)

CYCLOPTERINÆ (Bon.) Gill.

Body contracted. Dorsal fins, two, the first spinous.

Genus *Cyclopterus* Linn.

Plates in one dorsal, and on each side in two lateral and one abdominal rows. First dorsal very small.

Cyclopterus lumpus Linn.

Lumpus anglorum, Storer, Mem. Am. Ac. viii, 402, pl. 32, fig. 2.

LIPARIDINÆ GILL.

Body elongated. Dorsal single, entire.

Genus *Liparis* (Art.)

Teeth triscuspid. Ventral disk below posterior half of head.

Liparis ———.

Liparis vulgaris, Fortin in Rep. Com. Crown Lands, Canada, 1863, p. 161.

† *C. inornatus* has been signalized from Halifax by Mr. Jones, since the transmission of this article for publication, under the name of *C. maculatus*, (this Journal, p. 129, April, 1865).

SUB-ORDER PEDICULATI.

- I. Branchial apertures below, in or behind the inferior axillæ of the pectoral fins. Lower jaw projecting. LOPHIIDÆ.
- II. Branchial apertures above in the axillæ of the pectoral fins. Mouth subterminal or inferior, the lower jaw being received within the upper. MALTHEIDÆ.

LOPHIIDÆ (Raf.) Gill.

Genus *Lophius* (Linn.) Cuv.*Lophius Americanus* Val.*Lophius Americanus*, Storer, Mem. Am. Ac. v, 266, pl. xviii, fig. 2.

MALTHEIDÆ (BLKR.) GILL.

MALTHEINÆ Gill.

Disk heart-shaped, produced at the snout; body robust.

Genus *Malthe* Cuv.* *Malthe cubifrons* Rich.*Malthe cubifrons*, Rich., Fauna Bor. Am., Fishes, 103 (pl. 96).

SUBORDER JUGULARES.

- I. Branchial apertures very large, continuous, the membrane cleft far forwards. GADIDÆ.

GADIDÆ (Cuv.)

MERLUCIINÆ (Sw.) Gill.

Dorsal fins two; first well developed; second, as well as anal, emarginated behind middle.

Genus *Merlucius* Raf.*Merlucius bilinearis* Gill ex Mitch. Silver-hake of Grand Haven; Whiting of St. Johns. (Perley.)*Merlucius albidus*, Storer, Mem. Am. Ac. vi, 363, pl. 28, fig. 2.

GADINÆ (Bon) Gill.

Dorsal fins three; anal two.

Genus *Pollachius* (Nilss.)

Mouth moderate, lower jaw longer, with barbel obsolete or rudimentary.

Pollachius carbonarius Bon.* Pollock; Sea-salmon. (Perley.)*Merlangus purpureus*, Storer, Mem. Am. Ac. vi, 358, pl. 28, fig. 3.

Genus *Gadus* (Linn.) Bon.

Mouth large. Lateral line white. Anus under second dorsal fin. Size large.

Gadus morrhua Linn.

Gadus arenosus (Mitch.)† - Cod or Cod-fish.

Morrhua Americana, Storer, Mem. Am. Ac. vi, 343, pl. 27, fig. 4.

Genus *Microgadus* (Gill).

Mouth large. Anus under first dorsal fin. Size small.‡

Microgadus tomcodus (Walb.) Tomcod; Frost-fish. (Perley.)

Morrhua pruinosa, Storer, Mem. Am. Ac. vi, 357, pl. 27, fig. 5.

Genus *Melanogrammus* Gill.

Mouth rather small. Lateral line black.

Melanogrammus æglifinus Gill ex Linn. Haddock. (Perley.)

Morrhua æglifinus, Storer, Mem. Am. Ac. vi, 355, pl. 28, fig. 1.

PHYCINÆ (Sw.) Gill.

Dorsals two; anal one; Ventrals with styliform bases, generally forked.

Genus *Phycis* (Raf.)

Caudal convex behind.

Phycis chuss Gill ex Walb. Ling; American-hake. (Perley.)

Phycis filamentosus, Storer, Mem. Am. Ac. vi, 367, pl. 29, fig. 4.

Scales in about 110 transverse rows. Mouth blotched with dark purple inside.

Phycis tenuis Gill.

Phycis Americanus, Storer, Mem. Am. Ac. vi, 365, pl. 29, fig. 3.

Scales in 135—140 transverse rows. Mouth minutely punctulated with black within.

Genus *Urophycis* Gill.

Caudal emarginated behind.

Urophycis regius Gill.

Gadus (*Phycis*) *punctatus*, Rich. F. B. A. III, Fish p. 253, (wood-cut).

† Probably not distinct from *G. morrhua*.

‡ *Gadus* and *Microgadus* are trenchantly distinguished by important anatomical characters, for a knowledge of which reference is made to the Proc. Ac. Nat. Sc. Phila. 1865, p. 69.

LOTINÆ Gill.

Dorsals two; posterior as well as anal entire.

Genus *Lota* Cuv.

Anterior dorsal much behind scapular region. Teeth not enlarged.

Lota lacustris Gill ex Walb. Fresh-water cusk. (Perley.)

CILIATINÆ Gill.

Dorsals two; anterior fringed, with a longer ray in front.

Genus *Rhinonemus* Gill.

Head depressed behind, snout with cirrus.

Rhinonemus caudacuta Gill ex Storer. (Bell.)

Motella caudacuta, Storer, Mem. Am. Ac. vi, p. 361, pl. 29, fig. 1.

Genus *Ciliata* Coch.

Head and body compressed, *silvery*.

* *Ciliata argentata* Gill ex Reinh.

BROSMINÆ Sw.

Dorsal single.

Genus *Brosmius* Cuv.

Brosmius Americanus Gill.

Brosmius flavescens, Storer, Mem. Am. Ac.

Lower jaw shorter, with an undivided barbel.

Brosmius flavescens Les.*

Lower jaw longer, with a forked barbel.

SUB-ORDER HETEROSOMATA.

PLEURONECTIDÆ.

PLEURONECTINÆ, Gill.

Mouth small, the supramaxillary ending before or under front of eye.

Genus *Pseudopleuronectes* Blkr.

Body with imbricated etenoid scales. Teeth fixed, incisorial. Lateral line not arched in front.

Pseudopleuronectes Americanus Gill ex Walb. Common flounder. (Perley.)

Platessa plana, Storer, Mem. Am. Ac. viii, 389, pl. 30, fig. 2.

Platessa pusilla, Dek. (young).†

† *Platessa pusilla* DeKay = *Pseudopl. Americanus*, young.

Genus *Limanda* Gottsche.

Body with rough imbricated scales. Teeth fixed, incisorial.
Lateral line arched in front.

Limanda rostrata Gill. Fluke or common dab. (Perley.)

Platessa rostrata, Storer, Boston Jour. Nat. Hist., vi, pl. 8, fig. 2

HIPPOGLOSSINÆ Gill.

Mouth large. Ventrals lateral.

Genus *Hippoglossoides* Gottsche.

Body thick. Scales ctenoid; caudal entire.

* *Hippoglossoides platessoides* Gill ex Fab.

Hippoglossoides platessoides, Gill, Proc. Ac. Nat. Soc. 1864.

Genus *Pomatopsetta* Gill.

Body thin. Scales mostly cycloid, caudal entire.

Pomatopsetta dentata Gill.

Platessa dentata, Storer, Mem. Am. Ac. viii, 391, pl. 30, fig. 3.

Genus *Hippoglossus* Cuv.

Body robust, with minute smooth scales, caudal fin emarginated.

Hippoglossus Americanus Gill. Halibut. (Perley.)

Hippoglossus vulgaris, Storer, Mem. Am. Ac. viii, pl.

SUB-ORDER ABDOMINALES.

FAMILIES.

I. Head plane above and behind. Pectorals inserted rather high on the sides.

a. Body elongated, with the back and abdomen parallel.

Lateral line distinct, very low. SCOMBERESOCIDÆ.

β. Body oblong, subfusiform or oval, with no lateral line.

Head flat above, with large scales. POECILIIDÆ.

II. Head more or less convex transversely above. Pectorals inserted very low on sides.

a. Dorsal fin more or less in advance of anal.

* Adipose dorsal finlet present behind. A lateral line.

SALMONIDÆ.

** Adipose dorsal finlet none. No lateral line.

CLUPEIDÆ.

β. Dorsal and anal fins opposite, far behind.

* Head with oblong conical depressed snout.

ESOCIDÆ.

** Head rounded in front, with oblique tympanic and opercular apparatus, and an enormous mouth.

STOMIATIDÆ.

SCOMBERESOCIDÆ Bon.

SCOMBERESOCINÆ Gill.

Body compressed; jaws both produced, slender; dorsal and anal posterior rays developed as separate finlets.

Genus *Scomberesox* Lac.*Scomberesox scutellatus* Les.

Scomberesox scutellatus, Storer, Mem. Am. Ac. vi, 315, pl. 24, fig. 4.

BELONINÆ Bon.

Body little compressed; jaws both produced, strong and with well-developed teeth; dorsal and anal simple behind.

Genus *Belone* Cuv.*Belone longirostris* Gill ex Mitch.

Belone truncata, Storer, Mem. Am. Ac. vi, 314, pl. 24, fig. 3.

POECILIIDÆ Bon.

HYDRARGYRINÆ Gill.

Teeth acute. Dorsal and anal, generally subequal and opposite.

Genus *Hydrargyra* Lac.

Branchiostegal rays six.

Hydrargyra majalis Val. ex Walb. Mammy-chub. (Perley.)

Hydrargyra flavula, Storer, Mem. Am. Ac. v, pl. 23, fig. 5 (male, with 12 - 15 vertical bands), and 6 (female with 2 - 3 longitudinal lines).

Genus *Fundulus* Lac.

Branchiostegal rays five.

Fundulus pisculentus Val. Big killy-fish; Minnow. (Fortin.)

Fundulus pisculentus, Storer, Mem. Am. Ac. v, 294, pl. 23, fig. 3 (male, with vertical light bands), and fig. 4 (female, uniform).

SALMONIDÆ Cuv.

SALMONINÆ Bon.

Teeth acute. Stomach not cœcal; pyloric cœca numerous.

Genus *Salmo* (Linn.)

Body spotted in adults. Mouth large, with well-developed teeth.

Salmo salar Linn.

Salmo salar, Storer, Mem. Am. Ac. vi, 320, pl. 25, fig. 2.

Salmo sebago Grd. Togue. (Perley.)

Salmo sebago, Grd., Proc. Acad. Nat. Sc., Phila., 1853.

Salmo fontinalis Mitchell. Brook Trout. (Perley.)

Salmo fontinalis, Storer, Mem. Am. Ac. vi, 322, pl. 25, fig. 3.

Genus *Coregonus* (Art.) Ag.

Body never spotted. Mouth small, toothless, with the lower jaw shorter.

Coregonus ——. Gizzard-fish. (Perley.)

Coregonus albus, Perley, Report on Sea and River Fishes of New Brunswick, p. 204.

ARGENTININÆ (Bon.) Gill.

Teeth acute. Stomach cœcal, and at the pyloric extremity provided with few cœca.

Genus *Osmerus* (Art.)

Sexes scarcely distinguishable externally. Scales in both regularly imbricated. Pectorals and ventrals moderate (P. 10–12).

Osmerus mordax Gill ex Mitch. Smelt. (Perley.)

Osmerus viridescens, Storer, Mem. Am. Ac. vi.

Genus *Mallotus* Cuv.

Sexes very dissimilar: scales of the male villose or pointed in a lateral band; pectorals and ventrals very large and overlapping one another; scales of the female as in *Osmerus*. (P. 18–20.)

Mallotus villosus Cuv. Capelin. (Perley.)

Salmo (*Mallotus*) *villosus*, Rich. F. B. A., iii, Fishes, p. 187.

CLUPEIDÆ (Cuv.)

CLUPEINÆ (Bon.)

Body much compressed, fusiform. Head conic, with oral cleft longitudinal and the lower jaw projecting.

Genus *Clupea* (Linn.)

Scales simple. Upper jaw little emarginated at symphysis. Mouth well toothed.

Clupea elongata Les.

Clupea elongata, Storer, Mem. Am. Ac. vi, 330, pl. 26, fig. 1.

Genus *Alosa* Cuv.

Scales simple. Pre-opercular with a very short horizontal process; cheeks very high. Upper jaw deeply notched at symphysis. Mouth toothless, or with supramaxillars only toothed.

Alosa tyrannus Gill ex Lat.

Alosa praestabilis, Storer, Mem. Am. Ac. vi, 332, pl. 26, fig. 2.

Genus *Pomolobus* (Raf.) Gill.

Scales simple. Pre-operculum with an oblong horizontal process; cheeks longer than high. Upper jaw notched at symphysis. Roof of mouth edentulous.

Pomolobus pseudo-harengus Gill ex Wilson. Alewife; Gaspe-reau. (Perley.)

Alosa cyanonoton, Storer, Mem. Am. Ac. vi, 339, pl. 27, fig. 1.

Alosa tyrannus, Storer, Mem. Am. Ac. vi, 337, pl. 26, fig. 3.

Genus *Brevoortia* Gill.

Scales ciliated or pectinated behind!

Brevoortia menhaden Gill ex Mitch.

Alosa menhaden, Storer, Mem. Am. Ac. vi, 336, pl. 26, fig. 4.

ESOCIDÆ (Cuv.)

Genus *Esox* Linn.

Esox reticulatus Les. Pike; Pickerel. (Fortin.)

Esox reticulatus, Storer, Mem. Am. Ac. vi, 311, pl. 24, fig. 1.

STOMIATIDÆ GILL.

Genus *Malacosteus* Ayres.

Body naked. Gape rectilinear. Opercular bones much reduced.

* *Malacosteus niger* Ayres.

Malacosteus niger, Ayres, Boston Journ. Nat. Hist.

SUB-ORDER EVENTOGNATHI GILL.

1. Lower pharyngeal bones with 1-3 rows of teeth, the primary row containing only 5-7. CYPRINIDÆ.

2. Lower pharyngeal bones with a row of numerous pectiniform teeth. CATASTOMIDÆ.

CYPRINIDÆ (Cuv.) GILL.

Genus *Stilbuis* (Dek.) Gill.

Head and body much compressed, silvery. Back much arched. Lateral line very low.

Stilbuis Americanus Gill ex Lac. Shiner; Carp. (Perley.)

Leucosomus Americanus, Storer, Mem. Am. Ac. vi, 283, pl. 21, fig.

2. D. 9-10, A. 15-16, P. 15-17, V. 9.

Genus *Hypsilepis* Baird.

Head and body thick, the former large and short, with tubercles in the breeding season. Scales higher than long. Lateral line submedian, little decurved.

*Hypsilepis cornutus** Grd. ex Mit. Roach; Red-fin. (Perley.)

Hypsilepis cornutus, Storer, Mem. Am. Ac. vi, 284, pl. 21, fig. 3.

D. 8, A. 9, P. 15, V. 8.

Genus *Semotilus* Raf.

Head and body thick, elongated. Scales quadrate or oblong. Lateral line submedian, little decurved.

*Semotilus pulchellus** Gill. Roach-dace. (Perley.)

Cheilonemus pulchellus, Storer, Mem. Am. Ac. vi, 286, pl. 22, fig. 2.

D. 9-10, A. 9-10, P. 16-17, V. 8.

Genus *Rhinichthys* Ag.

Head and body thick, elongated. Scales oblong. Lateral line nearly straight, and generally with a black band extending from snout to caudal.

*Rhinichthys atronasmus** Ag. ex Mit. Brook minnow.

Argyreus atronasmus, Storer, Mem. Am. Ac. vi, 288, pl. 21, fig. 4.

D. 8, A. 8, P. 14-15, V. 8.

CATASTOMIDÆ GILL.

CATASTOMIDÆ (Heck.) Gill.

Dorsal short, above ventrals.

Genus *Catostomus* (Les.) Ag.

Snout long. Lateral line present, nearly straight. Lips papillated.

*Catostomus Bostoniensis** Les. Sucker.

Catostomus Bostoniensis, Storer, Mem. Am. Ac. vi, 290, pl. 22, fig. 3.

D. 14-16, A. 9, P. 18, V. 10.

Genus *Moxostoma* (Raf.) Ag.

Snout short. Lateral line obsolete. Lips plicated.

Moxostoma oblongum Ag. ex Mit. Chub. (Perley.)

Catostomus gibbosus, Storer, Mem. Am. Ac. vi, 291, pl. 22, fig. 4.

D. 15-17, A. 9-10, P. 16, V. 10.

ORDER APODES.

ANGUILLIDÆ Kaup.

Body with patches of oblong scales diagonally disposed.

Genus *Anguilla* Thunberg.*Anguilla Bostoniensis* St. ex Les. Eel. (Perley.)*Anguilla Bostoniensis*, Storer, Mem. Am. Ac. viii, 409, pl. 33, fig. 1.

The fish (*Leptocephalus gracilis*, Storer) regarded by me as being probably the larva of the conger, has been found along the coast of Maine.†

ORDER NEMATOGNATHI GILL.

SILURIDÆ (Cuv.) Blkr.

BAGRINÆ.

Genus *Amiurus* (Raf.) Gill.‡

Head depressed, with the supra-occipital free behind. Adipose fin well developed; caudal nearly even.

Amiurus———. Cat-fish. (Perley.)

Species uncertain; not seen by me.

ORDER PLECTOGNATHI.

SUB-ORDER SCLERODERMI.

BALISTIDÆ Cuv.

BALISTINÆ (Bon.)

First dorsal fin with two or three spines.

Genus *Capriscus* Sw.

Postbranchial scales enlarged; dorsal and anal elevated in front.

Capriscus fuliginosus Gill ex Dekay.*Balistes fuliginosus*, Dekay, N. Y. Fauna, p. 339, pl. 57, fig. 188.

(Nova Scotia. J. M. Jones, Esq., in litt.)

MONACANTHINÆ Kaup.

Dorsal spine single.

Genus *Stephanolepis* Gill.

Scales with a coroniform crest.

Stephanolepis Massachusetts * Gill ex Storer. (Jones.)*Monacanthus Massachusetts*, Storer, Mem. Am. Ac. viii, 425, pl. 34, fig. 4.† The *Anguilla* or *Isognatha oceanica* Dekay is the American Conger.‡ As the etymology of the name *Amiurus* has been variously misunderstood, one deriving it from *Amia* and *ovpa*, and another from *Αημ* (shovel) and *ovpa*, it will not be superfluous to state that it alludes to the "tail entire" (Raf.), and is formed of the privative *a* and *μειουρος* (curtailed). The name is a most happy one both in its reference to a marked generic character and in its concordance with its derivatives.

It may be here remarked that the Siluroids, Mormyroids, Stervarchoids, and Gymnotoids, are closely related.

ORDER LOPHOBRANCHII.

SYNGNATHIDÆ (Bon.)

SYNGNATHINÆ (Bon.)

Head and body much elongated and straight. Males with a caudal egg-pouch open throughout.

Genus *Syngnathus* Linn.

Body heptagonal, slender, with the breast-shields rugose, and the jaws sub-equal.

Syngnathus Peckianus Storer. (Dawson.)

Syngnathus Peckianus, Storer, Mem. Am. Ac. viii, 412, pl. 33, fig. 3.

GANOIDEI.

ORDER CHONDROSTEI.

STURONIDÆ (Rich.)

Genus *Acipenserine* (Bon.)

Both pseudobranchiæ and spiracula developed.

Acipenser oxyrinchus, Storer, Mem. Am. Ac. viii, 431, pl. 35, fig. 4.

ORDERS OF ELASMOBRANCHI.

Branchial apertures lateral.

SQUALI.

Branchial apertures inferior.

RAIÆ.

FAMILIES OF SQUALI.

I. Anal fin present.

A. Branchial apertures entirely in front of pectorals. Caudal nearly lunate. LAMNIDÆ.

AA Branchial aperture behind above pectoral.

B. Caudal with its upper lobe extremely long. Nictitating membrane obsolete. ALOPECIDÆ.

BB. Caudal with its upper lobe moderately elongate. Nictitating membrane of eyes present.

GALEORHINIDÆ.

II. Anal fin absent.

Dorsals with spines in front.

SPINACIDÆ.

Dorsals without spines.

SCYMNIDÆ.

LAMNIDÆ Mull. et Henle.

LAMNINÆ Gill.

Branchial aperture moderate. Teeth well developed.

Genus *Isuropsis* Gill.

Teeth nail-shaped, long, prismatic and acute. Dorsal nearly midway between pectorals and ventrals.

Isuropsis glaucus Gill ex M. & H. Porbeagle. (Fortin.)

Lamna punctata, Storer, Dekay.

CETORHININÆ Gill.

Branchial apertures extremely large. Teeth minute.

Genus *Cetorhinus* Blainv.

Cetorhinus maximus Gray ex Linn. Basking-shark. (Perley.)

Selachus maximus, Dekay.

ALOPECIDÆ Owen.

Genus *Alopias* Raf.

Alopias vulpes Bon. ex Linn. Thresher-shark. (Perley.)

Carcharias vulpes, Dekay.

GALEORHININIDÆ GILL.

GALEORHININÆ Gill.

Teeth compressed, trenchant, entire or crenulated.

Genus *Scoliodon* Mull. & Henle.

Teeth with smooth edges, and with point directed towards the corners of the mouth.

* *Scoliodon terræ-novæ* Gill ex Rich.

Squalis (carcharias) terræ-novæ, Rich., F. B. A., Fishes, 289.

SPINACIDÆ (OWEN).

Genus *Squalus* (Linn.) Raf.

Teeth of jaws similar, subquadrate, with a nearly horizontal cutting-edge.

Squalus Americanus Gill ex St. Dog-fish. (Perley.)

Spinax acanthias ? Dekay.

SCYMNIDÆ (OWEN).

Genus *Somniosus* Les.

Teeth above narrow, triangular; below subquadrate, with a nearly horizontal cutting-edge.

Somniosus microcephalus (Gray).

Scymnus brevipinna, Dekay.

FAMILIES OF RAIIÆ.

RAIIDÆ (Bon).

Genus *Raia* Linn.*Raia laevis* Mitchill. Skate (Perley.)*Raia laevis*, Dekay, N. Y. Fauna, 370.*Raia erinacea* Mitchill. Hedge-hog ray. (Perley.)*Raia erinaceus*, Dekay, N. Y. Fauna, 372, pl. 78, fig. 276.

The identification of these species requires confirmation.

MARSIPOBRANCHIÆ.

ORDER HYPEROARTÆ.

SUB-ORDERS.

Palate not perforated.

HYPEROARTII.

Palate perforated by the posterior aperture of the naso-palatine tube.

HYPEROTRETI.

PETROMYZONTIDÆ Bon.

Genus *Petromyzon* (Linn.) Gray.

Palatal teeth two, conic, closely approximated. Lingual teeth two, serrate.

Petromyzon Americanus Say. American lamprey. (Perley.)*Petromyzon Americanus*, Dekay, N. Y. Fauna, 379, pl. 66, fig. 216.

ORDER HYPEROTRETI.

MYXINIDÆ Mull.

Genus *Myxine* Linn.*Myxine glutinosa* Girard.**Myxine glutinosa*, Girard Proc. Acad. N. S. Phila. 1888.

SUPPLEMENTARY NOTE.

Having been recently engaged in a revision of the classification of the fishes of our coast, I embrace this opportunity of remarking that the Sparoids are among those hitherto misunderstood. The *Pagrus argyrops* Cuv., *Sargus arenosus* Dekay, and *Sargus ambassis* Gunther, should be united and referred to a new genus which differs widely from both *Pagrus* and *Sargus*; the teeth in front are trenchant and compressed but very narrow, and in front

of the dorsal there is a recumbent spine. The genus may be named *Stenotomus*.* The *Sargus probatocephalus* agrees with *Stenotomus* and differs from *Sargus* in being armed with a recumbent dorsal spine, and may be called *Archosargus*.† The anatomical and full generic characters will be hereafter exposed.

I may also add that among the Cyprinodonts, the *Fundulus zonatus* Cv., *F. cingulatus* Cv., and *Hydrargyra luciae* Baird, should be separated from *Fundulus* and *Hydrargyra*, to form a distinct genus, (*Micristius* ‡) distinguished by its physiognomy and the small number of dorsal rays. The nominal species probably represent sexual conditions.

Another family involved in great confusion is that of the Clupeidæ. An examination of extensive material has convinced me that the number of species has been very much over-estimated and that too much attention has been paid to the dentition. The various osteological modifications, &c. afford much safer characters I can only recognize with certainty seven species of Clupeinæ as inhabitants of the eastern coast to the northward.

1. *Clupea harenqus* L. (Greenland fide Reinhardt, &c.)
2. *Clupea elongata* Les.
3. *Pomolobus mediocris* Gill ex Mitch. = *Meletta mattawocca*, Cv.
—*Alosa lineata* Storer.
4. *Pomolobus pseudo* = *harenqus* Gill ex Wilson = *Clupea virescens* Dekay.—*Alosa cyanonoton* St. = *Meletta venosa*, Cv. = *Alausella parvula* Gill, (y.g.) = *Alosa tyrannus* Storer
—*Clupea fasciata* Les.
5. *Clupanodon thrissa* Lac. = *Meletta thrissa* Cv. = *Opisthonema thrissa* Gill.
6. *Alosa tyrannus* Gill ex Latrobe = *Alosa praestabilis* Dekay.
7. *Brevoortia menhaden* Gill ex Mitchell = *Alosa menhaden* Cuv.
Washington City, U.S.A., Aug., 1865.

* Στενος, narrow ; τομς, incisive. The narrow incisors are especially characteristic of *Stenotomus*.

† Αρχων, ruler ; Σάργος, *Sargus*. The sheeps-head (*Archosargus probatocephalus*) is pre-eminent among the Sparoids for the delicacy of its flesh as well as its size.

‡ Μικρος, small ; ιστιον, sail. *Micristius* is well distinguished by its small dorsal fin.

GEOLOGICAL SKETCH OF THE NEIGHBORHOOD
OF ROSSIE.

BY THOMAS MACFARLANE.

Having in April last spent nearly a week in and around Rossie, St. Lawrence County, State of New York, and made some observations which appear to me of importance in connection with the economic minerals occurring there, I have thought myself justified in attempting briefly to describe the relations of the rocks and ore deposits of this interesting locality. This has no doubt been already done to some extent by the officers of the Geological Survey of the state of New York, and I should not probably have ventured on this sketch had I not satisfied myself of the existence, in the district to which it has reference, of certain zones of rock which in Norway are termed "fahlbands," and which are found there to exercise a very important influence on the contents of mineral veins. In a paper contained in vol. vii. of this Journal, I gave a full description of these fahlbands, the presence of which in the Laurentian rocks affords another proof of the identity of that series with the Primitive Gneiss of Scandinavia.

The rocks which occur in the neighbourhood of Rossie belong almost exclusively to the Laurentian formation. Here and there the gneissoid rocks are unconformably overlaid by patches of Potsdam sandstone, and the latter rock most likely at one time covered the whole area of the district, but has since been removed by denudation. The following are the principal rocks which occur in the neighbourhood of Rossie, and which belong to the Primitive Gneiss or Laurentian formation :

Gneiss, both micaceous and hornblendic. The feldspar, quartz, and mica in the former sort, are often intimately combined with each other in bands of considerable thickness. Quite as frequently, however, the mica with a smaller quantity of feldspar and quartz forms narrow bands alternating with other bands destitute of lamination, and consisting of a coarsely granular mixture of feldspar and quartz; so that this gneiss in reality is a compound of very micaceous gneiss and pegmatite. The micaceous varieties of the gneiss occur principally to the south and southeast of the village of Rossie, while that of a hornblendic character is principally developed on the north and west. It is worthy of remark that while the feldspar in the micaceous gneiss is for the most part white, in the hornblendic variety it is reddish coloured. On the road to Depeyster

the latter sort of gneiss predominates; and there tourmaline often occurs in it, forming a very beautiful rock. Occasionally the quartz disappears, and a schistose syenite is the result. There are even bands wherein very little slaty structure is discernible, and the rock of which, did it occur in larger masses, would undoubtedly be termed syenite.

Mica schist would appear to exist in this district, at least in such narrow bands as those of the micaceous gneiss above referred to. It would seem also occasionally to occur as the rock of the fahlbands hereafter to be described.

Gneiss-granite. In many places to the south of Rossie, and especially near the lead-veins on the farm of John Robb, the gneiss, at least when hand-specimens of it are examined, exhibits mere traces of parallel structure; and on this account, as well as because of its being finely granular, it might reasonably be termed gneiss-granite.

Granite. Besides the narrow granitic bands above referred to which enter into the composition of gneiss, many veins of granite occur which cross the gneissoid strata, sometimes in very great numbers, and presenting an appearance similar to that described by Macculloch as visible at Cape Wrath.

Tourmaline rock. In the district of syenitic gneiss which lies to the north-west of Rossie, there occur some irregular masses of quartz in which tourmaline is so plentifully disseminated as to form the schôrlfels of German geologists.

Crystalline limestone is very extensively developed in the neighborhood of Rossie, and indeed it constitutes the storehouse from which are obtained the greater number of the rare and beautiful minerals, for which Rossie is celebrated. Like the same rock in Canada, it is coarsely granular and sometimes saccharoidal. The general color is white, although grey bands are of frequent occurrence. These latter seem to owe their color to disseminated laminae of graphite,—and indeed it is difficult to find a piece of the limestone which is entirely free from this mineral.

Diorite. This name may probably with justice be given to a rock which occurs to the west of Rossie, and which forms the side-rock of a vein of magnetic and iron pyrites which has been explored to a considerable extent for copper. It consists mainly of greenish-white albite (some of the cleavage planes of which exhibit a slight change of color), dark-green hornblende, and translucent quartz. Besides these minerals there are also crystals of sphene present in small quantity.

The general strike of the schistose rocks above mentioned is north and south (magnetic). Although there are often very wide deviations from this course, they seldom go beyond N. 45° W. and N. 45° E., the deviations to the eastward being much more frequent than those in a westerly direction. Occasionally the rocks may seem to run due east and west, but this is only in small areas, and owing to local contortions of the strata. These contortions are often of the most surprising and intricate character, and remind the observer of the figures formed by the foam of a river when it has reached comparatively still water, and is acted on by currents flowing with different degrees of rapidity or in different directions. They also bear a resemblance to the contortions visible on many pieces of slag which may be picked up on the heaps produced at the Rossie iron-furnaces. In fact, the edges of such pieces, showing bands of different color and grain in beautiful convolutions, present a miniature counterpart of the upturned edges of the contorted gneissoid strata. As in all primitive regions, these strata assume in Rossie an almost vertical position. On the east side of the Indian River a few beds are observable dipping about 5° west; but very generally the strata are highly inclined, and if not quite vertical, only a very few degrees removed from it.

It will be observed that the rocks of this district coincide closely in their various characters with the same rocks in other and far-distant primitive regions; and when we reflect that they possess the same general strike and inclination, the same mineralogical constituents and modes of aggregation, it is impossible to avoid forming the conclusion that they are the products of some processes of vast magnitude and force, which must have been in operation at the same time over the whole of the earth's surface, and during the very earliest stages of its development. Assuming these processes to have been of plutonic nature, the general north and south strike of all primitive stratified rocks might be supposed to represent the general direction of the flow of the igneous material from the solidification of which the rocks resulted.

Among the economic minerals occurring in Rossie, an important place is occupied by the ores of lead and iron. Several very important veins containing the former were explored many years ago with success, and are at present being worked quite extensively. The veinstone of the Coalhill, Victoria and Union lodes consist principally of calcespar and galena, with occasional traces of fluor-spar and copper pyrites. These lodes cut the gneissoid strata

almost at right angles to the run of the latter, and their dip deviates but very little from the vertical. Sir W. E. Logan (Geology of Canada p. 689) considers it possible that the lead-veins of Bedford and Landsdowne, C. W., belong to the same series as those of Rossie. The former seem however to be especially associated with crystalline limestone, and it would seem to be a question of interest and importance as to whether the lodes of Rossie traversed this rock, and if so, whether it had any influence upon them. To judge from a plan of the workings of the Coalhill mine, shown to me at Rossie, there would seem to occur in it so-called *shoots* of ore; but whether these bear any definite relation to the character of the side-rock, has not been ascertained. The investigations of Herman Müller of Freiberg have shown that the nature of the wall-rock has much influence on the contents of the metallic veins of the Erzgebirge, and he divides the gneiss of that region into grey and red, the former exerting a favorable and the latter an unfavourable influence on the contents of the lodes passing through them. It is not improbable that the same varieties of gneiss may occur near Rossie, and influence in a like manner the lodes of that district.

Besides the lead-veins which are now being worked, numerous others have been discovered, especially on the lands of John and William Robb. The ore is galena, in calcespar, which occasionally contains also iron pyrites in small quantity. The wall-rock is the granitic gneiss mentioned among the rocks of the district, and the general strike of these veins differs from that of the older ones of Coalhill, Victoria, and Union mines. They would seem to belong to a different series, having a general strike of about N. 50° W. and an almost vertical dip. Several of these veins are well worthy of exploration, not only in depth, at the points where they have been uncovered, but also where they cross the other rocks of the country, especially the limestones and fahlbands.

Rocks of the latter description exist in the immediate neighborhood of the lead-veins just referred to. My attention was first attracted to them by observing pieces of rock much resembling a well-weathered fahlband on a ploughed field in the farm of William Robb. By tracing these southward the rock itself was soon found exposed on the road leading across the farm. It had here a strike of almost north and south (the bearings given are to be always understood as magnetic), which carried it to the southward beneath another ploughed field. On crossing this to the south it

was again found out-cropping, and from this point to beyond John Robb's house it was traced uninterruptedly. About half way between the latter place and the spot where the rock was first found, the strike changes to N. 22 East, which direction it maintained to the southward as far as it was followed. This fahlband was therefore actually traced for a distance of about a mile, but it doubtless extended much further. I have in the paper already referred to (Canadian Naturalist, vol. vii, p. 7) given a minute description of these rocks and the ore-deposits which occur in connection with them in Norway, but it may be advantageous here to recapitulate their general characters. A fahlband (the first syllable being most probably derived from the German word *fahl* or *faul*, rotten) is a zone of rock occurring in the Primitive Gneiss formation varying from a few to several hundred feet in thickness, having a length on the strike of several miles, and possessing the same dip and strike as the rocks adjoining it, but distinguished from them by the decomposed appearance and reddish-brown color which it assumes on exposure to the atmosphere. This peculiar brown weathering is caused by the oxidation of the magnetic and iron pyrites with which the rock is impregnated, the ferric oxide resulting from their decomposition being the coloring substance. The quantity of these sulphurets of iron necessary to produce this effect is often exceedingly small; and indeed it is sometimes scarcely possible to distinguish them even in the freshly broken and undecomposed rock, so finely disseminated are they through it. By the help of the magnifying glass they can, however, always be detected in any part of the rock which exhibits the reddish-brown surface above mentioned. The impregnation is altogether independent of the nature of the rock; gneiss, mica-schist, and hornblende-schist being alike found constituting fahlbands. Their course is often marked by depressions in the rocks, caused probably by their greater proneness to decomposition. Almost all the mines of any importance in the south of Norway, with the exception of those of iron, occur on bands having the characters above described. Silver, cobalt, nickel, and copper have all been found in very remunerative quantities within this peculiar rock, either in veins crossing the band (silver) or disseminated through it more or less plentifully in fine grains (cobalt), or in irregular masses sometimes rudely parallel with the strike (copper, nickel).

The band of red-weathering rock above described as occurring to the south-west of Rossie has all the characters of a fahlband. The

impregnating sulphurets are distinctly recognisable; the breadth is sometimes over 200 feet; the length on the strike is considerable; (one mile at least), the strike is the same as that of the enclosing rocks, and the fahlband itself is a micaceous gneiss. Depressions on its course are frequent, and it would seem to occupy the low cultivated land which lies behind John Robb's house. The only particular wherein it differs from the same rock in Norway is in being accompanied on the east side by a band of crystalline limestone, which often weathers brown and is much decomposed, and in being, so far as explorations have heretofore shown, destitute of any valuable minerals. Its true character being now known, however, it is possible that future exploration, if concentrated upon this zone of rock, may develop some metaliferous deposits of value.

On the east side of Indian River, and near the town-line between Rossie and Antwerp, another fahlband occurs, this time unaccompanied by crystalline limestone, containing traces of copper-ore, and therefore presenting a complete analogy with the fahlbands of Norway. This fahlband is found on the land of Mr. Lyon in Antwerp, close to the road which, towards the north, joins the plank-road between Clarkshill and Oxbow. Owing to the decomposed state of the rock of this fahlband, it is difficult to recognise its mineralogical constituents; but it is more micaceous in character than the one on John Robb's farm. Its strike when first observed was N. 37° E, the strata being as usual almost vertical. A few fathoms distant from it, on the eastern side, some exploration had been done, and pieces of copper-ore said to have been discovered. In the excavation itself I could discover no trace of copper; but lying among the debris from it pieces seemingly of pyrites very much decomposed were observed, which, on assay, were found to contain 4.6 per cent of copper. The rock in this excavation was altogether different from that of the fahlband, and much resembled the diorite described among the rocks of the district. A short distance from this place, towards the north on the fahlband, a small vein ($\frac{1}{4}$ to $\frac{3}{4}$ inch wide) occurs crossing it at right angles nearly, and containing almost pure copper pyrites. A small quantity picked out of the vein assayed 25.4 per cent copper. Following the fahlband to the northward, it continues on the east side of the road, changing its strike to N. 31° E. (dip to N. W., 89°), then to N. 50° E, when it diverges further from the road. A few hundred yards to the eastward of the road a three-foot vein of

calcspar occurs, containing copper pyrites in small grains scattered through it, the quantity so small as merely to bring the contents of the best pieces up to $\frac{1}{2}$ per cent. The strike is, however, such as to intersect the fahlband, and it might be important to explore it where it does so, as its character might there alter, and possibly its contents in copper pyrites increase. This fahlband was traced altogether a distance of three quarters of a mile on the strike, but had time been devoted to its exploration, it would probably have been found continuous along a much greater distance.

Traces of fahlbands, or at least of brown-weathering rocks, occur at many other points, and there would seem good reason for supposing that there exist in Rossie a tolerable number of such fahlbands running rudely parallel with each other, the tracing out of which, and their exploration for minerals of value, might be attended with important results.

In the south-eastern part of the town of Rossie, the very extensive deposits of iron ore occur, which formerly supplied the Rossie iron furnaces, and the working of which has very lately been resumed. Open workings have been carried on at four different points, called respectively the Old Caledonia, New Caledonia, Kearney and Keene ore-beds. The first-named working consists of several excavations made into the face of a ridge consisting mainly of iron ore. The rock which forms the most elevated part of this ridge is probably a part of the Potsdam sandstone. The upper layers are comparatively soft and of undoubted detrital character. As it approaches the underlying iron ore, however, it becomes excessively hard, assumes almost the vitrified appearance of some quartzites, and becomes slightly mixed with ore. A little below this, and filling the interstices between fragments of ore, a brown-spar is sometimes found, which seems to be a mechanical mixture of the carbonates of iron and lime in the proportion of 16.2 per cent of the former to 83.8 per cent of the latter. Beneath the indurated sandstone lies a great mass of iron ore which is at least forty feet thick vertically. It consists of compact amorphous hematite, with which more or less silicious and calcareous matter is intermixed. Occasionally cavities are found in the interior of the ore filled with various minerals, and one of these I observed contained calcspar and transparent rhombic prisms of heavy spar. In the richest and densest pieces of the ore small fissures occur containing graphite, and indeed this mineral seems to be disseminated through all the ore in more or less considerable quantity. A specimen of this best ore contained, on examination,

Matter insoluble in acid, principally graphite.....	18.90
Peroxide of iron = 57.45 per cent. of the metal.....	82.05
	<hr/>
	100.95

Another specimen which was considered less rich than that just mentioned, but containing less disseminated graphite, and more of it in crystalline scales occurring in the cracks, gave,

Silicious matter, insoluble in acids.....	7.4
Peroxide of iron = 64.84 per cent. of the metal.....	92.6
	<hr/>
	100.0

Besides these qualities, an immense quantity of ore is worked which is evidently mixed with very considerable portions of argillaceous and calcareous matter. A specimen of this character gave on analysis as follows:

Silicious matter, insoluble in acid.....	36.20
Peroxide of iron = 34.76 per cent. metallic iron.....	49.65
Carbonate of lime.....	12.90
	<hr/>
	98.75

In none of the excavations does the underlying rock appear to have been reached, and since outside of the workings the underlying red shales have a strong dip towards the deposit, there would seem reason for supposing the existence of a large body of ore even below the level of the present excavations. To the west of the ore-bed, and apparently dipping underneath the above-mentioned red shales, other slates occur, very richly impregnated with iron pyrites. Beyond these, and nearer the New Caledonia bed, vertical strata of micaceous schist are observable. The excavation on the New Caledonia bed was filled with water, but similar relations seem prevail there as at the Old Caledonia. At the former deposit, however, the overlying sandstone is not only very much hardened in contact with the ore, but is broken up into a breccia, the interstices of which are filled up with highly siliceous ore. On the whole, it would seem as if all the iron deposits of this neighborhood had been formed at the same time and in the same manner, and they may have even constituted parts of one and the same original mass. At Keene's ore-bed, about a mile distant from the Caledonia workings, the geological relations are the same, although the overlying sandstone is much brecciated, and it, as well as the

bed of the ore, and the underlying shale, deviates very much from the horizontal. Two specimens of ore taken from this bed contained,

	Best ore.	Inferior ore.
Silicious matter	4.80	2.18
Peroxide of iron	93.15 = 65.22 iron	66.00 = 46.21 iron.
Carbonate of lime	2.05	32.40
	<hr/> 100.00	<hr/> 100.55

Since the ore together with silica often forms the cement of the breccia above mentioned, it is highly probable that the sandstone was deposited, and also disturbed prior to the formation of the masses of ore. With regard to the origin of the latter, it is impossible to regard them as igneous products, when we consider the large amount of earthy matter which they contain. And, further, the absence of specular iron ore would seem to indicate that they could not have been the result of any process of sublimation. There only remains, therefore, as adequate to explain their mode of formation, the theory that the ore was introduced into its present bed in the state of solution, and deposited there by means of some precipitating agent. A slight degree of heat may subsequently have been instrumental in converting the precipitate into anhydrous peroxide of iron.

There only remains to mention, in connection with the economic minerals of Rossie, the vein of magnetic and iron pyrites occurring in the diorite already described. A very considerable amount of exploration has been done on this vein in search of copper, but mere traces only of copper pyrites are sometimes observable close to the quartz which forms part of the veinstone. The magnetic pyrites contains no nickel, and the least trace of cobalt. The iron pyrites, on the other hand, contains no nickel and 0.85 per cent. of cobalt.

I here conclude this geological sketch of Rossie. It is necessarily very incomplete from the limited time at my disposal when visiting that place. I trust, however, that it will be found to contain a few facts of interest.

Acton Vale, C. E., 29th May, 1865.

CONTRIBUTIONS TO THE CHEMISTRY OF NATURAL WATERS.

By T. STERRY HUNT, LL.D., F.R.S.; of the Geol. Survey of Canada.

III.

CHEMICAL AND GEOLOGICAL CONSIDERATIONS.

CONTENTS OF SECTIONS.—52, salts of alkaline metals, proportion and sources of potash; 53, potash in a borax lake, in the primitive sea; 54, salts of lime and magnesia, relations of chlorids and carbonates; 55, solubility of earthy carbonates; 56, super-saturated solutions of carbonates of lime and magnesia; 57, salts of barium and strontium, solution of their sulphates; 58, iron manganese, alumina and phosphates; 59, bromids and iodids; the small portion of bromine and the excess of iodine in saline springs as compared with the modern ocean; 60, probable relation of iodids to sediments; 61, sulphates, their elimination from waters; 62, water holding a soluble sulphuret; 63, borates, their detection and determination; 64, analysis of a borax water from California; 65, carbonates, their amount in the Caledonia water; 66, intervention of neutral carbonate of soda; 67 deficiency of carbonic acid in waters; 68, reactions of various waters; 69, silica, its source and its proportion; 70, its conditions; formation of silicates; 71, organic matters; 72, geological position of the waters here described; 73, succession of paleozoic strata; lithological relations of successive formation; 74, Quebec group, its waters; 75, sources of various classes of waters; 76, their relation to the formations; 77, association of unlike waters, changes in constitution; 78, temperature of springs, thermal waters; 79, geological interest of the above analyses; possible results of the evaporation of these springs; 80, relations of mineral springs to folding and to metamorphism of strata; 81, on the supposed origin of the primeval ocean and the earliest sediments; 82, on the theory of metalliferous deposits.

§ 52. SALTS OF THE ALKALINE METALS.—These salts abound in most saline waters, and except in the few cases in which sulphate of magnesia prevails, form a large part of the soluble matters present. The salts of sodium are by far the most abundant, and the proportion of potassium salt is generally small. The chlorid of potassium in modern sea-water constitutes three or four hundredths of the alkaline chlorids, while in the brines from old rocks, and in saline waters of the first two classes alike from Germany, England, the United States, and Canada, its proportion is much less, sometimes amounting to traces only. In the waters of classes III and IV, where alkaline carbonates appear, and even predominate, the proportion of potassium salt becomes greater.

Thus of the waters of the latter class (§ 45), the alkalies of the Nicolet spring calculated as chlorids contain 1.89 per cent of chlorid of potassium, and those of the Jacques-Cartier 2.95; while for the St. Ours spring the chlorid of potassium is equal to not less than 25.0 per cent. There does not however appear to be any relation between the proportion of alkaline carbonate and that of potassium, since the salts from the waters first named are more alkaline than those of St. Ours; while those of the alkaline water of Joly contain less than one per cent of potassic chlorid.

The amount of this salt obtained from the water of the Ottawa River is worthy of notice, being equal to not less than 32.0 per cent of the alkaline chlorids, while in the waters of the St. Lawrence it amounts to 16.0 per cent.* A large proportion of potassium relatively to the sodium has already been observed in the case of many ordinary river and spring waters, and this is readily explained when we consider the extent to which potash is set free by the decomposition of both vegetal and mineral matters at the earth's surface. The process by which this base is eliminated in filtering through soils has already been explained in § 5. The occasional presence of considerable amounts of potash in sulphated mineral waters (Lersch, *Hydro-chemie*, p. 346) is explained by the power of solutions of gypsum to set free this alkali from soils (§ 7), and also probably in some cases by the dissolution of double potassic salts like polyhallite. Strata holding glauconite, which occurs alike in paleozoic and more recent formations,† may also be conceived to yield potash salts to infiltrating waters.

§ 53. It will be seen that the waters above noticed, in which the proportion of the potash to the soda is large, are but feebly saline, so that the real amount of potassium is in no case great. I have however recently examined the water of a borax lake from California, which contains in 1000 parts 17.250 of solid matters of which 1.818 is carbonate of potash, the remainder being soda-salts, carbonate, borate, chlorid, and a little silicate, with no sulphate

* T. S. Hunt, L. E. and D., *Phil. Mag.* (4) xiii. 239; and *Geology of Canada*, page 565.

† For a notice, with analyses by the author, of a green hydrated silicate of alumina, iron and potash, allied to glauconite, from the paleozoic rocks of Canada and of the Mississippi valley, see the *Geology of Canada*, pages 487, 488; where also will be found an analysis by the author of the glauconite from the Cretaceous formation of New Jersey. See also *illiman's Journal* [2], xxxiii. 277.

(§ 64). This amount, if represented as chlorid of potassium, is equal to 1.963, or to 11.46 per cent of the alkalies calculated as chlorids. The amount of potassium salt in this water is consequently about forty times greater than in that of St. Ours.

The fact of special importance as regards the alkaline metals in the waters whose analyses we have given in this paper is the very small amount of potassium in the strongly saline muriated waters of the first three classes, which we conceive to be more or less directly derived from the waters of the ancient ocean. To this primeval sea, almost destitute of potassium, the process of mineral decay has been for ages adding potash salts, and despite the partial elimination of these by vegetation (§ 5), and by the formation of glauconite, we find a notable proportion of potash in the waters of the modern ocean.

In the analyses of the saline waters here given lithia was sought for in a few instances, and was detected in the waters of Varennes. Most of these analyses were made before the discovery of the new metals cæsium and rubidium.

§ 54. SALTS OF CALCIUM AND MAGNESIUM.—We have to consider under this head the relations both of the chlorids and the carbonates of these bases. The bitter saline waters of the first class, although containing large quantities of chlorids of calcium and magnesium, are, as we have seen, generally destitute of earthy carbonates. These latter, however, are found in small quantities in the alkaline waters of the fourth class, and in somewhat larger amounts in those intermediate waters which form classes II and III, and are apparently formed by admixtures of the two classes previously mentioned. Besides the carbonates of lime and magnesia which the waters of the fourth class hold in solution, the carbonate of soda which they contain gives rise, by its re-action with the chlorids of calcium and magnesium, to additional quantities of the carbonates of these bases. In the waters of Kingston, (§ 36), a large amount of chlorid of calcium is associated with earthy carbonates, and these waters thus offer a passage from the first to the second class.

In most of the waters of the second class, as will be seen from the table § 42, there appears but a small amount of chlorid of calcium; and even this depends upon the manner in which the analysis has been conducted. We may suppose in the recent water such a partition of bases between the chlorine and the carbonic acid that chlorid of calcium, chlorid of magnesium, bicarbonate of lime

and bicarbonate of magnesia co-exist. When such a solution is submitted to evaporation at ordinary temperatures, provided there is present a sufficient amount of chlorid of calcium, carbonate of lime alone is deposited, and chlorid of magnesium remains in solution.

In case the chlorid of calcium is insufficient, the lime is still first deposited as carbonate, and the more soluble magnesian carbonate is precipitated by further evaporation. When however such a water is boiled, a reverse process takes place; the carbonate of lime slowly decomposes the magnesian chlorid, and carbonate of magnesia is deposited, while chlorid of calcium remains in solution. Hence if the amount of chlorid of magnesium be great enough, and the ebullition sufficiently prolonged, the precipitate will at length contain only carbonate of magnesia; while an equivalent of chlorid of calcium, now found in the solution, represents the carbonate of lime which the analysis of the precipitate at an earlier stage of the ebullition would have furnished.

As an example of this may be cited the analysis of the water of Ste. Genevieve (§ 42, No. 8), where the precipitate after a few minutes boiling contained carbonates of lime and magnesia in the proportion 12 : 750. When however another portion was boiled down to one sixth, the precipitate was found to be pure carbonate of magnesia. Again, the Plantagenet water gives, by ebullition, the results set forth in § 42, No. 1; showing chiefly carbonate of magnesia, together with a portion of chlorid of calcium. When however this water is left to spontaneous evaporation, the whole of the lime separates as carbonate, and the liquid remains for a time charged with carbonate of magnesia, probably as sesqui-carbonate. This solution is however after a time spontaneously decomposed even in closed vessels, with deposition of a portion of crystalline hydrated carbonate of magnesia; another portion remains in solution, together with chlorid of magnesium, but is precipitated by ebullition. (Silliman's Journal [2], xxvii. 173.)

§ 55. Bicarbonate of magnesia and chlorid of calcium, when brought together in solution, undergo mutual decomposition with separation of carbonate of lime if the solutions are not too dilute. At the ordinary temperature and pressure, water saturated with carbonic acid will not hold in more than about one gram of carbonate of lime to the litre (1 : 1000); equal to only 0.88 grams of carbonate of magnesia. (The solubility of carbonate of lime in pure water is well known to be much less, and is, according to

Bineau, equal to 1 : 30,000 or 1 : 50,000.) We should not therefore expect to find that water holding chlorid of calcium in solution would yield, by boiling, more than the latter amount of magnesian carbonate; so much might evidently be formed by the action of dissolved carbonate of lime which the water might hold as bicarbonate. I have elsewhere described a series of experiments on the solubility of bicarbonate of lime both in pure water and in saline solutions, and have shown that the presence of salts of soda, lime and magnesia does not increase the amount of bicarbonate of lime which water is capable of holding *permanently* in solution. In view of these facts it seems at first sight difficult to explain how a mineral water like that of Kingston (§ 36, No. 7), holding a large quantity of chlorid of calcium, could yield, as appears from Dr. Williamson's analysis, 1.287 grams of carbonate of magnesia, equal to 1.462 of carbonate of lime to the litre. Recent experiments have however shown me that supersaturated solutions of a certain stability may be obtained, in which comparatively large quantities of neutral carbonates of lime and magnesia exist in the presence of sulphates and chlorids of calcium and magnesium. Reserving for another occasion a description of the details of these investigations, I shall briefly state the results obtained.

§ 56. In a memoir on the salts of lime and magnesia published in 1859 (Silliman's Journal [2] xxviii. 171), it was shown that by the addition of bicarbonate of soda to a solution holding chlorids of sodium calcium and magnesium, with or without sulphate of soda, and saturated with carbonic acid, it was possible to obtain transparent solutions holding from 3.40 to 4.16 grams of carbonate of lime to the litre; of which however the greater part was deposited after twenty-four hours; when the solutions were found to contain somewhat less than 1.0 gram in the form of bicarbonate. Boutron and Boudet had previously shown that by saturating lime-water with carbonic acid, solutions were obtained holding in a litre 2.3 grams of carbonate of lime; of which one half was soon deposited, even when the solution was kept under a pressure of several atmospheres. It would thus seem that saline liquids favor this temporary solubility of the carbonate of lime.

In all of the above experiments, an excess of carbonic acid was present, but this I have since found is not essential, since super-saturated solutions may be obtained holding as much as 1.2 grams of carbonate of lime, together with sulphate of magnesium and chlorid of calcium, in a litre of water, without any

excess of carbonic acid. The power of alkaline chlorids and of chlorid of calcium to prevent the precipitation of chlorid of calcium by carbonate of soda has already been observed by Storer, (*Dictionnaire of Solubilities*, p. 110). I have found that the precipitate produced by the admixture of solutions of these two salts is readily dissolved, when recent, by a solution of chlorid of calcium, or of sulphate of magnesia; and thus liquids may be prepared holding at the same time from 1.0 to 1.2 grams of neutral carbonate of lime, and 1.00 of neutral carbonate of magnesia, in presence of sulphate of magnesia. These solutions of carbonate of lime, which are strongly alkaline, may be kept for twelve hours or more without perceptible change at ordinary temperatures, but after a time deposit crystals of hydrated carbonate of lime. The addition of alcohol immediately throws down the whole of the carbonate of lime in an amorphous condition.

The carbonate of magnesia is still more soluble than the carbonate of lime under similar conditions, and it is possible to obtain 5.0 grams of neutral carbonate of magnesia dissolved in a litre of water holding seven per cent of hydrated sulphate of magnesia, without any carbonic acid. These solutions, which are strongly alkaline to test-papers, yield a precipitate by heat, which re-dissolves on cooling.

It is evident that the mingling of saline and alkaline waters may give rise to solutions like those just described, and thus explain apparent anomalies in composition like that of the Kingston water. See also in this connection the observations of Bineau, and my own on the properties of solutions of sesqui-carbonate of magnesia. (*Silliman's Journal* [2] xxvii. 173.)

§ 57. SALTS OF BARIUM AND STRONTIUM.—As will be seen from the preceding tables, the salts of these two bases are found in very many of the saline and alkaline waters of Canada. Their carbonates probably sustain to the magnesiàn chlorid a similar relation with that of calcium, and hence these bases appear in some of the analyses partly as carbonates, and partly as chlorids of barium and strontium. The precipitate formed in the concentrated and acidulated water by dilute sulphuric acid was, whenever submitted to analysis, found to contain both barium and strontium. For the separation of these the mixed sulphates were first converted into chlorids; the barium was then thrown down as silico-fluorid, and the strontium subsequently precipitated by a solution of gypsum.

The insolubility of its sulphate must have excluded baryta from

the waters of the primeval sea, and when set free, as we may suppose by the decomposition of its silicated compounds existing in the primitive crust, (§ 81) its soluble bicarbonate carried down to the sea would there be precipitated by the sulphates present. A similar process must still go on with all the dissolved barytic salts which find their way to the ocean.

The sulphate of baryta thus accumulated in sedimentary strata, may be partially decomposed by infiltrating solutions of alkaline carbonates, and thus be rendered capable of being subsequently dissolved as carbonate; but the most probable mode of its solution, is, we conceive, through its previous reduction by organic matters to the form of a soluble sulphuret (§ 10), ready to be converted into carbonate or chlorid of barium. In this way we may explain the frequent occurrence of baryta salts in the saline waters of the first three classes, and the consequent absence of sulphates, which will be further considered in § 61. From the similarity of its chemical re-actions, the preceding remarks apply to strontia as well as baryta.

§ 58. IRON, MANGANESE, ALUMINA AND PHOSPHATES.—None of the waters of the four classes here described contain any notable quantity of iron, yet this element is never wanting in those waters which contain earthy carbonates. Whenever a portion of one of these waters, or better the earthy precipitate separated from it by boiling, is evaporated to dryness with an excess of hydrochloric acid, the residue treated with acidulated water yields a portion of silica, and the solution will then be found to yield with ammonia a precipitate. This, which is partially soluble in caustic alkalies, is often colorless, and will be found to consist of alumina and peroxyd of iron, with phosphoric acid and a trace of manganese, which latter metal is seldom or never absent. The small quantity of alumina which these waters contain appears not to be derived from suspended argillaceous matters, but to be held in a state of solution.

The phosphates are generally present only in very small quantities in these waters, for the reason pointed out in § 5. The largest amount which I have met with was in an alkaline water from Fitzroy (§ 43, No. 4); where it is equal to .0124 of tribasic phosphate of soda in 1000 parts of water.

§ 59. BROMIDS AND IODIDS.—The chlorids in these ancient mineral waters are always accompanied by bromids and iodids, but the proportion of the bromids to the chlorids appears to be

much less than in the waters of the modern seas. According to Usiglio, 100 parts of the salts from the Mediterranean contain 1.48 of bromid of sodium; while ten analyses by Von Bibra of the waters of different oceans, give from 0.86 to 1.46, affording for 100 parts of salts, a mean of 1.16 of bromid of sodium, equal to 1.04 parts of bromid of magnesium. The waters of Whitby and Hallowell, on the contrary, which are the richest in bromids of those described in this paper, contain only 0.54 and 0.69 parts of bromid of sodium in 100 parts of solid matters; while few of the saline springs of the second class contain more than one-half of this proportion, and some of them very much less.

With regard to the iodids in many of these waters, however, the case is very different. The waters of the modern ocean, as is well known, contain but traces of iodine, and in some strongly saline springs of the first class, like that of Whitby, it is only in the alcoholic extract of the salts from this water that iodine can be detected. The Hallowell water (§ 36, No. 3), which closely resembles this in its general composition, and in the proportion of bromids, is however so rich in iodine that its presence can readily be discovered without previous evaporation. It is sufficient to add to the recent water acidulated by hydrochloric acid, a little solution of starch, and a few drops of nitrite of potash to produce an intense blue color. The iodid of sodium in the first-named water was found equal to 0.0017 parts of the solid matters, and that of the second to 0.019 or nearly twelve times as much. The unconcentrated saline waters of Ste. Genevieve, of the second class, also give a strong re-action for iodine, and when acidulated with hydrochloric acid, without previous evaporation, yield with a salt of palladium an insoluble precipitate of iodid of palladium after a few hours. The salts from these two springs of Ste. Genevieve, though poorer in bromids, are much richer in iodids than the waters of Hallowell; the spring No. 8, containing in 100 parts of salts no less than 0.138 of iodine, so that there appears to be no constant proportion between the chlorids, bromids, and iodids of these saline waters.

§ 60. The relations of bromids and iodids to argillaceous sediments have yet to be determined. It would appear from the facts just cited that bromine has in the course of ages been slowly eliminated from insoluble combinations, and like potassium, has accumulated in the waters of the ocean; while the facts in the history of iodine seem to point to a process the reverse of this;

in other words, to a gradual elimination of iodine from the sea-waters, and its fixation in the earth's crust. The observations of numerous chemists unite to show the frequent occurrence of small portions of iodine in some unknown combination, in sedimentary rocks of various kinds; from which we may conjecture that it was in former times abstracted from the sea, either directly or through the intervention of organic bodies (as in the case of potash, which is separated and fixed by means of algæ, § 5). Experiments after the manner of those of Way and Voëleker may throw light upon this interesting question. We are aware that insoluble combinations of soluble chlorids with silicates of alumina are formed under certain conditions, as appears in the generation of sodalite, eudyalite, and the chloriferous micas, and it is not improbable that the soluble iodids may give rise to similar compounds. By such a process might be explained the rarity of this element in modern seas, while the occasional re-solution of the iodine from these insoluble compounds by infiltrating waters, would help to explain the variable and often large proportions in which this element is met with in some of the waters noticed above.

§ 61. SULPHATES.—In the preceding sections we have already discussed the principal facts in the history of those neutral waters in which sulphates predominate, or prevail to the exclusion of chlorids (§ 50, 51.) The history and the probable origin of those curious springs which contain free sulphuric acid has also been considered (§ 31, 48, 49); and it now remains to notice the relation of sulphates to the muriated waters. The first fact that excites our attention is that of the total absence of sulphates from numerous springs of the first, second and third classes; as shown in the preceding analyses, and also in the observations of Lenny and others on the saline waters over a great area in western Pennsylvania (§ 40).

The elimination of sulphate in the form of gypsum from evaporating waters containing an excess of chlorid of calcium, has already been discussed in § 37; but the bitterns resulting from such a process still retain small portions of sulphates; while it is to be remarked that the saline waters under consideration contain no traces of sulphates, and in many instances hold portions of baryta and strontia, bases incompatible with the presence of sulphates. The modes in which this complete elimination of sulphates may be effected are two in number. The first has already been suggested in § 10, and depends upon the deoxydizing power of organic matters, which reduce the sulphates to sulphurets. These in their turn may be

converted into carbonates, the sulphur being separated either as sulphuretted hydrogen (giving rise by oxydation to free sulphur,) or as insoluble metallic sulphurets. This reducing action not only decomposes the soluble sulphates of soda, lime and magnesia, but also, as has been pointed out in § 57 may extend to sulphate of baryta and thus sulphuret or carbonate of baryta be formed. It is the action of these soluble baryta salts which constitutes the second mode of desulphatizing waters; and this, if we may judge from the frequency with which baryta salts occur in the saline waters in question, appears to have been the most general process.

It is a fact worthy of notice that a saline spring at Sabrevois near Lake Champlain, which holds both baryta and strontia in solution, is at the same time slightly impregnated with sulphuretted hydrogen. Another saline and sulphurous spring, which rises within ten feet of this, contains however a portion of sulphates. (Geology of Canada, page 542.)

§ 62. I am indebted to Prof. Croft of Toronto, for some notes of a recent examination by himself of a saline of the first class, which contains at the same time a soluble sulphuret. This water, from a boring sunk to a depth of several hundred feet through the Devonian limestone at Chatham, Canada West, had a specific gravity of 1039.3, and yielded for a thousand parts about 51.0 of solid matters. It contained large portions of chlorids of calcium and magnesium, with very little sulphate, traces of carbonate, and no free carbonic acid. The water, which gave an alkaline reaction with turmeric, was greenish in color, very sulphurous to the taste, and yielded a purple color with nitro-prussid of sodium, and a black precipitate of sulphuret with a solution of sulphate of iron. A current of carbonic acid rendered the recent water opalescent, and by exposure to the air it deposited sulphur. A quantitative analysis of this water is to be desired.

§ 63. BORATES.—The reddening of the yellow color of turmeric paper in presence of free hydrochloric acid, affords, with certain precautions, the ordinary means for detecting small portions of boric acid. Most of the waters of the third and fourth classes, and some of those of the second have been tested in this way, and have never failed when reduced to a small volume, and acidulated with hydrochloric acid, to give this reaction; which was however most marked with the waters of the fourth class. The determination of the amount of boric acid in saline waters presents no small difficulty. In the case of the alkaline water of Joly (§ 45, No. 3) the

following process was however attempted. The salts left by its evaporation were treated with carbonate of ammonia to separate a portion of silica, and then with recently precipitated carbonate of silver, by which the alkaline chlorids were converted into carbonates. The solution now retained in some undetermined form a portion of silver, which was separated by fusing the evaporated saline residue in a silver crucible. By a second evaporation and fusion there was obtained a mixture of soda and potash, combined only with carbonic, sulphuric and boric acids. By directly determining the other ingredients the boric acid was estimated from the loss, and was found equal to 0.028 parts in 1000 of water, which contained 0.752 of solid matters. The conversion into carbonate of the sulphates in the mixed salts, by the aid of bicarbonate of baryta, would simplify this process. In § 35 it has been explained that the amount of carbonate of soda in the waters of the third and fourth classes was generally calculated from the excess of the alkaline bases, and controlled by the amount of carbonate of baryta precipitated from chlorid of barium by the alkaline salt. It was found, however, that this last method always presented a certain deficit, due to the borate of soda, whose quantity in many of the waters, is too large to be disregarded. The precipitate of carbonate of baryta contained a portion of sparingly soluble borate of baryta, which was not completely removed by long and continued washing.

§ 64. I have recently had an opportunity of examining from California the waters of a borax lake, which contains, beside borate and carbonate of soda, a portion of chlorid, and a little silicate, traces only of phosphate, and no sulphate. It held in solution very small quantities of earthy carbonate, and was remarkable for a large proportion of potash, already referred to in § 53. The evaporated and fused saline residue was treated by the ordinary methods for the determination of the chlorine, carbonic acid and silica; while the bases were obtained in the form of sulphates by the aid of sulphuric and hydrofluoric acids, and afterwards separated as chlorids by the aid of chlorid of platinum. From the data thus obtained the following ingredients were found by calculation for 1,000 parts of the water :

Carbonate of soda.....	9.476
Biborate of soda.....	4.395
Chloride of sodium... ..	1.702
Carbonate of potash.....	1.818
Silica.....	0.129

17.520

The potassium, as above determined, equals 11.46 per cent. of the bases weighed as chlorids; another trial gave 11.41. Although for convenience we have represented the potassium as carbonate, it will be seen that the amount of chlorine is such that it might, for the greater part, have been represented as chlorid of potassium, with an equivalent portion additional of carbonate of soda.

§ 65. CARBONATES.—In describing in § 43 the alkaline-saline waters of Caledonia it has been shown that these contained a quantity of carbonic acid insufficient to form bicarbonates with the carbonated bases present. It was partly with this fact in view that, after an interval of more than seventeen years, I undertook the new analyses of these waters, which in § 47 are given side by side with the earlier results. In these recent analyses, as there remarked, a slight excess of carbonic acid was met with. In the interval the springs had undergone changes in composition, and while the third one still retained in a slight degree its alkaline character, the other two had become waters of the second class, holding instead of carbonate and sulphate of soda, chlorid of magnesium, and baryta salts. The amount of carbonic acid had however undergone but little change; and as will be seen by comparing the figures below with those in the table in § 47, the slight diminution in the first and third corresponds very closely with the falling off in the amount of solid matters between 1847 and 1865; while, on the contrary, the augmentation in the amount of carbonic acid in the second is accompanied with a corresponding increase in the amount of fixed matters present.

CARBONIC ACID IN ONE LITRE OF THE CALEDONIA WATERS.

	1847.	1865.
Gas spring.....	.705 gram.	.671 gram.
Saline spring.....	.648 "	.664 "
Sulphur spring.....	.590 "	.573 "

While the amounts of fixed matters and of carbonic acid in the several waters have undergone but little change, we find, however, that there has been a great diminution in the proportion of carbonated bases. Thus in the Gas spring in 1847 the carbonic acid required for the neutral carbonates found in the analysis was .356, while for the same water in 1865 only .278 of carbonic acid was required. In the Sulphur spring, in like manner, the neutral carbonates required .449*, or more than three-fourths of

* By mistake this is printed .349 in § 43.

the carbonic acid present; while the falling off in the amount of carbonates in 1865 is such that only .191 of carbonic acid, or just about one-third of the carbonic acid present, is required for the neutral carbonate. Nor is this change due entirely to a less amount of carbonate of soda; the carbonates of lime and magnesia in 1847 required .246, and in 1865 only .153 of carbonic acid. The changed conditions which we here meet with may be explained by supposing that the carbonated bases are due to the mingling in different proportions of neutral carbonate of soda (generated by the reaction indicated in § 13,) with an earthy saline water holding a constant amount of free carbonic acid; which, in some cases, is more than is required to form bicarbonates, but in others, as we have seen above, presents a deficiency.

§ 66. If we admit, as I have already assumed, that the waters of the second and third classes have been generated by the mingling of solutions of carbonate of soda with waters of the first class, it can readily be shown that these solutions contained chiefly or exclusively the neutral carbonate. If we add a solution of bicarbonate of soda to earthy saline waters of the first class it is easy to obtain solutions of holding twenty grams or more of bicarbonate of magnesia to the litre; while in none of the natural waters of the second class do our analyses show the existence of much over one gram to the litre. Again, if we suppose any considerable amount of chlorid of calcium to be decomposed by bicarbonate of soda, the separation of the lime in the form of neutral carbonate, and the liberation of the second equivalent of carbonic acid, would yield waters holding an excess of carbonic acid above that required to form the bicarbonates of the solution. From the absence of such an excess, as appears in the case of the waters of Caledonia, Varennes, St. Leon and Caxton, and from the small amount of bicarbonate of magnesia in these waters, it may be concluded that the alkaline salt whose addition has changed their character was the neutral carbonate of soda.

§ 67. Examples are not wanting of waters in which, as in those of Caledonia in 1847, the carbonic acid is insufficient to form bicarbonates, or even neutral carbonates, with the bases uncombined with sulphuric acid or chlorine. Thus, according to Pagenstecher and Müller, the spring and well-waters of Berne do not contain sufficient carbonic acid for the lime present, a part of which they suppose to be held in solution as a silicate. See Bischof, *Chem. Geology*, i. 5; who remarks that Löwig seems to have observed the

same fact in the thermal spring of Pfaffers. For further examples of this kind, see Lersch, *Hydro-Chemie*, page 333. The carbonic acid in the water of Töplitz is, according to him, not sufficient to form bicarbonates unless the silica present be supposed to be combined with a portion of bases; while in the alkaline thermal spring of Bertrich, according to the analysis of Mohr, a similar deficiency of carbonic acid exists; leading to the conclusion that a part of the earthy bases present is in combination with silica and organic matters. The existence of solutions holding comparatively large amount of neutral carbonates of lime and magnesia, as described in § 56, is not without interest in this connection; since it at once affords an explanation of the nature and origin of all such alkaline waters, and waters deficient in carbonic acid, as contain earthy sulphates and chlorids.

§ 68. It was found that the waters of Chambly in 1864, and of the Sulphur spring of Caledonia in 1865, gave with lime-water a precipitate which was soluble in an excess of these mineral waters, but to a much less extent than in the acidulous saline water from the High-Rock spring of Saratoga. The latter, which contains bicarbonate of soda, and is highly charged with carbonic acid, turns to a wine-red the blue color of litmus tincture, which is not changed by the Chambly or the Caledonia water. The Saratoga water, after some time, gives a feeble alkaline reaction with dahlia paper; this is more distinctly but slowly changed by the Caledonia water, and almost immediately turned to green by that of Chambly. This latter water readily browns yellow turmeric paper, which is scarcely affected by the water of Caledonia.

§ 69. SILICA. The silica which exists in solution in cold saline springs is generally very small in amount, as might be expected from the insolubility of earthy silicates, which is such that superficial drainage waters in filtering through the soil lose the silica which they held in solution (§ 5). We have further shown that as a result of this tendency to the formation of insoluble silicates, the silicate of soda liberated in the sediments by the decomposition of feldspar, generally appears at the surface as carbonate of soda, having been decomposed by earthy carbonates (§ 13).

In two cases, however, considerable quantities of silica are found dissolved in natural waters. The first is met with where the rapid solvent and decomposing action of heated waters is exerted upon alkaliferous silicious minerals (§ 14), as seen in springs like the Geysers. The second case is that of those rivers and streams

which drain surfaces covered with decaying vegetation and decomposing silicates, from both of which they derive dissolved silica. Such waters contain but small amounts of solid matters, but the proportion of silica is relatively considerable, amounting, as we have seen in the water of the Ottawa River, (which contains in 10,000 parts, 0.6116 of solid matters), to 0.2060, or thirty-two per cent.; while in the St. Lawrence, which contains for the same amount of water, 1.6056, the silica equals .3700, or twenty-four per cent. of the solid ingredients. The analysis by H. Deville of the river-waters of France show, in like manner, large amounts of silica, which seem to have been hitherto overlooked in the analyses of most chemists. (Ann. de Chim. et Phys. [3], xxiii, 32.)

It will be seen by a reference to the tables of analyses given in the second part of this paper, that in the waters of the second class the amount of silica is equal to from 0.15 to 0.60 parts for 100.00 of solid matter. In the alkaline waters of the third and fourth classes its proportion is greater, and up to a certain point appears to increase with that of the carbonate of soda. In the following table the proportions of carbonate of soda and silica for 100.00 parts of solid matters are given for certain springs, whose analyses will be found in tables III and IV :

	III 1	III 5	III 2	III 6	III 4	III 8	III 3	III 7	IV 1	IV 3	IV 2	IV 5
Carb. soda.....	.6	1.6	2.4	3.4	7.0	8.0	9.2	21.0	25.0	30.0	56.0	6.7
Silica .....	.4	.4	.6	.6	1.6	1.5	1.7	2.9	3.0	3.2	3.2	32.0

The amount of silica which these waters contain does not in any case exceed one or two ten-thousandths, and it is well known that water at the ordinary temperature may dissolve very much more than this amount of silica, even in the presence of alkaline chlorids and of bicarbonates.

§ 70. Inasmuch as carbonic acid, according to Bischof (Chem. Geol. i, 2), decomposes not only the silicates of soda, but those of lime and magnesia when they are in solution, it might be supposed that the silica in the above waters exists either in a free state or as a soluble silicate with a great excess of acid. The latter view, especially in the case of magnesia, is rendered probable by numerous experiments which I shall describe in another paper, which form a part of the series already mentioned in § 41. From

these it appears that free soluble silica, when mingled with a solution of bicarbonate of magnesia, or with the neutral carbonate dissolved in sulphate of magnesia in the manner described in § 56, whether separating immediately or by a slower process of gelatinization, always carries down with it, in combination, a few hundredths of magnesia.

In these experiments, besides the carbonate of magnesia, sulphate or chlorid of magnesium was present; but the silicated natural waters now under discussion are alkaline from the presence of carbonate of soda, and whatever partition of bases between carbonic and silicic acids may exist in the recent waters, we may suppose that when they are boiled a silicate of soda is formed, with the expulsion of carbonic acid. The silicate thus produced reacts on the earthy bases present with the production of silicates of lime and magnesia, which are in part precipitated with the earthy carbonates. Berzelius and Kersten long since observed the separation of such silicates during the evaporation of the waters of Carlsbad and of Marienbad (Bischof. i, 5); while a silicate of lime is said to be deposited from the waters of Wiesbaden. But the silicates thus formed are but partially precipitated—a portion remaining in solution till a late period of the evaporation. Dr. J. Lawrence Smith long since remarked the existence of a dissolved silicate of lime, apparently combined with soda, in the concentrated alkaline waters of Broosa in Asia Minor. (Silliman's Journal [2], xii, 377.)

Many facts in accordance with the above were observed in the analyses of the waters described in this paper. Thus the water of Belœil, which held in 1000 parts .114 of silica, when evaporated to one-tenth deposited with the carbonates .050 of silica; and the hydrochloric solution of the precipitate became gelatinous during evaporation. The solution still retained in solution, besides a portion of lime, .064 of silica; which was completely separated when the alkaline liquid was evaporated to dryness in contact with the earthy carbonates previously precipitated. When however these were removed by filtration it was found that during the evaporation to dryness a reaction took place by which the precipitated silicate of lime was partially decomposed, the separated silica being redissolved by the alkaline carbonate. In the case of the Chambly water of 1852, which contained in 1000 parts .073 of silica, .042 parts still remained in solution in the water evaporated to one twentieth; and in that of the Ottawa River when reduced to one

fortieth there still remained in solution from 10,000 parts of water, .075 of silica and .028 of lime. Similar results were observed with the alkaline saline waters of Varennes and Fitzroy; and all of these yielded, by further evaporation, precipitates containing silica and lime, and in one instance magnesia.

It is not however from alkaline waters like these, but from neutral sea-water that the silicates of magnesia (and of lime), which abound in stratified rocks, have been for the most part formed. See farther on this point, § 41.

§ 71. ORGANIC MATTERS. In § 44 we have described some of the reactions of the organic matter found in the Chambly water, and it is to be remarked that small portions of a similar substance were found in all alkaline waters of the third and fourth classes, and caused them to become brownish when evaporated to a small volume. This, it has been already suggested, may have a superficial origin, the organic matters carried down by surface-waters being kept in solution by the alkaline salts; it is not however impossible that this same menstruum may remove the organic matters which abound in the pyroschists and other materials of organic origin in the ancient rocks. Thus for example the coprolites of the Lower Silurian limestones contain so much animal matter as to evolve an odor like burning horn when exposed to heat. (Geology of Canada, 462).

The Ottawa water (§ 45, No. 5), when boiled to one-tenth, deposits a precipitate in small bright brown iridescent scales. This was found to contain silica, carbonate of lime and a small portion of an organic substance which was dissolved in dilute potash ley. The brown solution thus obtained was not disturbed by acetic acid and acetate of copper, but by the subsequent addition of carbonate of ammonia yielded a white precipitate. The concentrated water retained a large proportion of organic matter, and when reduced to a small bulk, was dark brown, alkaline to turmeric paper, and continued by evaporation to deposit opaque films of silicate of lime. The finally dried residue was dark brown in color, and carbonized by heat, burning like tinder and diffusing an agreeable odor. The residue of 10,000 parts dried at 300° F. weighed .6974, and lost by gentle ignition .1635, consisting partly of organic matter.

No chemical examination was made of this matter held in solution by the concentrated water. From the late researches of

Peligot, however, it appears that the organic matter precipitated by nitrate of lead from the water of the Seine has nearly the composition of the apocrenic acid of Berzelius. It gave on analysis carbon 53.1, hydrogen 2.7, nitrogen 2.4, oxygen 41.8, and is evidently related to the soluble form of vegetable humus. (*Comptes Rendus*, April 25th, 1864.) When exposed to heat this substance evolved ammonia, with the odor of burning wool, while the organic matter from the Ottawa water, on the contrary, gave an odor like burning turf.

GEOLOGICAL POSITION OF THE PRECEDING WATERS.

§ 72. The great paleozoic area of the St. Lawrence basin is divided into two basins by an axis extending from Deschambault, not far above Quebec on the St. Lawrence, in a south-west direction to Lake Champlain. The eastern part of the western basin is more or less affected by undulations subordinate to the great fault that brings up the Quebec group against the Hudson-River formation, and also by other undulations of minor importance. It is in this disturbed region that by far the greater number of the mineral springs already described occur; and although it is often difficult to establish the presence, or to trace the extent of faults in the strata, on account of the alluvial deposits which generally cover the paleozoic strata of the region, it is apparent that in a great number of cases the mineral springs occur along the lines of disturbance, and it is probable that a constant relation of this kind exists.

As the eastern limit of the western basin is approached, the mineral springs become more numerous, but this boundary once passed, a region is soon reached where the rocks become profoundly altered, and furnish no more mineral waters. The great western portion of the occidental basin, which is less disturbed than its eastern part, presents but few mineral springs; yet the wells of strongly saline water which have been obtained by boring at Kingston, Hallowell, St. Catherines, Chatham, and elsewhere, show that the undisturbed rocky strata are charged with saline matters. For a better understanding of the relations of these waters, a list of the paleozoic formations in which the mineral springs here described occur, is given on the next page, numbered in ascending order.

PALEOZOIC FORMATIONS.

15. HAMILTON,—shales.
14. CORNIFEROUS,—limestone.
13. ORISKANY,—sandstone.
12. ONONDAGA OR GYPSIFEROUS,—dolomite.
11. GUELPH,—dolomite.
10. NIAGARA,—dolomite.
9. CLINTON,—limestone and shale.
8. MEDINA,—sandstone.
6. HUDSON RIVER,—shales.
5. UTICA,—shales.
4. TRENTON,—limestone.
3. CHAZY,—limestone.
2. CALCIFEROUS,—dolomite.
1. POTSDAM,—sandstone.

§ 73. Of the above series the Trenton group includes the Birds-eye and Black River limestone, as well as the Trenton limestone of the New York geologists, and is non-magnesian, enclosing beds of chert, silicified fossils, and petroleum; in all of which characters it resembles the Corniferous limestone above. In like manner the Potsdam is represented by the Hudson-River and Medina formations, while the gypsiferous dolomite of the so-called Calciferous sand-rock corresponds to the great mass of dolomite which constitutes Nos. 10, 11, and 12, and includes the gypsum and the salt-bearing strata of the Onondaga formation. These repetitions of similar strata, marking successive recurrences of similar geological and geographical conditions, which form great cycles in the history of the continent, have been already considered in a paper by me on Bitumens, etc., in Silliman's Journal [2], xxxv, 166.

§ 74. In the eastern basin, which includes not only south-eastern Canada, but the whole of New England, the strata are in an altered and crystalline condition, if we except a narrow belt along the north-west border of the basin. These unaltered strata present a great series of shales, conglomerates, and limestones, pure and magnesian, succeeded by 2000 feet or more of sandstones, with shales; the whole forming what the Canadian Geological Survey has named the Quebec group, whose aggregate thickness in the vicinity of Quebec is about 7000 feet. The geological horizon of this group of strata corresponds to that of the Chazy, the Calciferous, and perhaps of the Potsdam. It was in great part a deep-sea deposit, of which the formations just named are but incomplete and littoral representatives. Of the waters described

in this paper none are from this eastern basin, although the unaltered portions of it present several mineral springs, some of which are described in the *Geology of Canada*. Of these, the salines of Cacouna, Green Island, Rivière Ouelle and Ste. Anne, are bitter waters belonging to the first class; while a sulphurous spring at the latter place, and another at Quebec are alkaline waters of the fourth class.

§ 75. Of the waters of the western basin, which alone are noticed in this paper, many have been qualitatively analyzed which are not here described. Including two from Vermont, twenty-one alkaline waters of the third and fourth classes have been examined. Of these, as already stated, the waters of Caledonia rise from the Trenton group, and that of Fitzroy from the Chazy or Calceiferous, while two others, at Ste. Martine and Rawdon, appear to have their source in the Potsdam. All the other waters of these two classes issue from the Hudson-River shales, with the exception of those of Varennes and Jacques Cartier, which seem to rise from the Utica formation.

Of the waters of the second class, of which about thirty have been examined from the western basin, some five or six issue from the shale formations Nos. 5 and 6, but all the others are from the underlying limestones. The bitter salines of the first class flow from the limestones of the Trenton group, with the exception of that of Ancaster, which is from a well sunk in the Niagara formation, and that of St. Catherines, from a boring carried through the Medina down into the Hudson-River shales. The source of both of these is probably, like that of the other very similar waters, the Lower Silurian limestones.

§ 76. From this distribution of the waters of the first four classes it would appear that the source of the neutral salts, which consist of alkaline and earthy chlorids, is in the limestones and other strata from the Potsdam to the Trenton inclusive, while the alkaline carbonates are derived from the argillaceous sediments which make up the Utica and Hudson-River formation. These sediments are never deficient in alkaline silicates, whose slow decomposition yields to infiltrating waters (§ 13) the alkaline carbonates which characterize the mineral springs of the fourth class. These, mingling in various proportions with the brines which rise from the limestones beneath, produce the waters of the second and third classes in the manner already explained. The appearance of several springs of the third class, as those of Caledonia and Fitzroy, from the Lower

Silurian limestones is not surprising, when it is considered that the Chazy formation in the Ottawa valley includes a considerable thickness of shales, sandstones and argillaceous limestones, approaching in composition to the sediments of the Hudson-River formation.

§ 77. As an evidence that the different classes of waters have their origin in different strata may be cited the fact that springs very unlike in composition are often found in close proximity, and apparently rising from a common fissure or dislocation. Thus in the seigniories of Nicolet and Labaie du Febyre, I have examined six springs, all of which rise through the Utica formation along a line, in a distance of about eight miles. Of these springs two belong to the second, two to the third, and two to the fourth class; these last being probably derived entirely from the shales, while the others have their source in the underlying limestones, and are more or less modified in their ascent. Again, at Sabrevois, within a few feet are two springs of the second class, of which one contains salts of baryta and strontia, and the other soluble sulphates. In like manner at Ste. Anne, in the Quebec group, a spring of the second class and one of the fourth are found not far apart. The springs of Caledonia offer another and not less remarkable example. In 1847 there were to be seen, not far from a spring of the second class, three others of the third class very near together, one of them sulphurous, but all sulphated, and differing in the proportions of carbonate of soda present. In 1865, while one of these still retained its character of a sulphurous sulphated water of the third class, the others were changed to waters of the second class, and held salts of baryta in solution. These relations, which we have already pointed out (§ 47), not only show waters holding incompatible salts issuing from different strata along the same fissure, but mingling in such varying proportions as to produce from time to time changes in the constitution of the resulting springs.

§ 78. The temperature of none of the springs which we have here described exceeds 53°, which has been observed for two springs at Chambly, about twelve miles from Montreal. Inasmuch as the mean temperature of this city, as deduced from the observations of twenty-seven years, is 44°.67, the Chambly waters are to be regarded as slightly thermal. No other springs in Canada are known to present so high temperature, unless possibly the acid waters of the fifth class, for which we have pointed out the importance of farther observations (§ 48). The St. Léon spring was found to be 46°, and that of Caxton, 49° F.

§ 79. The extended series of analyses which we have given in the preceding pages presents many points of interest. Nowhere else, it is believed, has such a complete systematic examination of the waters of a region, and of a great geological series been made. Additional importance is given to these results by the fact that the waters are all derived from paleozoic strata, and we are thus enabled to compare these saline materials of an ancient period with those which issue from, and in many cases owe their saline impregnation to strata of comparatively modern origin. Comparisons of this kind, such as I have already instituted between brines of different geological epochs in § 39, possess great geological interest.

It is a consideration not without interest, that the valley of the St. Lawrence under different meteorological conditions might become a region abounding with saline lakes, affording sea-salt, natron and borax, the results of the evaporation of the numerous saline and alkaline springs which have just been described.

§ 80. A few considerations are here suggested by the fact already mentioned of the apparent absence of mineral springs from the altered paleozoic strata of the Quebec group. Metamorphism and disturbance or displacement of strata are generally concomitants, not, as I conceive, because the process of alteration is in any way connected with the disturbance of the rocks, but because a great accumulation of superincumbent strata, a necessary preliminary of metamorphism, is the efficient cause of the folding of the deeply buried and subsiding rocks, in a way which I have already elsewhere pointed out.* The subsequent continental uplifting of the altered, plicated, and more or less fissured strata, and their irregular erosion, give rise to the broken surfaces of metamorphic regions, and at the same time permit the saline solutions impregnating the strata to flow out; while solid soluble salts, unless enclosed by impermeable strata, are removed by lixiviation. Hence we shall rarely find muriated waters issuing from crystalline and disturbed strata. Those saline products which result from the decomposition of feldspathic minerals, and the separation of alkaline carbonates; or from the decomposition by these, or other agents, of the gypsum which is often present in metamorphic strata, may, however, readily give rise to waters of the fourth and sixth classes; so that we are not surprised to find alkaline and sulphated waters issuing from crystalline strata.

* Silliman's Journal [2], xxxi, 412.

§ 81. I have in a previous section (§ 57) alluded to the condition of the primeval ocean, and in this connection it may be well to refer to a hypothesis which I some years since advanced to explain the origin of its salts and the primeval sediments, Starting from the notion "of a cooling globe, such as the igneous theory supposes our earth to have been at an early period, and considering only the crust with which geology makes us acquainted, and the liquid and gaseous elements which now surround it, I have endeavored to show that we may attain to some notion of the chemical conditions of the cooling mass by conceiving these materials to again re-act upon each other under the influence of an intense heat. The quartz, which is present in such a great proportion in many rocks, would decompose the carbonates and sulphates, and, aided by the presence of water, the chlorids both of the rocky strata and of the sea; while the organic matters and the fossil carbon would be burned by the atmospheric oxygen. From these re-actions would result a fused mass of silicates of alumina, alkalies, lime, magnesia, iron-oxyd, etc.; while all the carbon, sulphur and chlorine, in the form of acid gases, mixed with watery vapor, nitrogen, and a probable excess of oxygen, would form an exceedingly dense atmosphere. When the cooling permitted condensation, an acid rain would fall upon the heated surface of the earth, decomposing the silicates, and giving rise to chlorids and sulphates of the various bases, while the separated silica might take the form of crystalline quartz. In the next stage of the process, the portions of the primitive crust not covered by the ocean would undergo a decomposition under the influence of hot moist atmosphere charged with carbonic acid, and the felspathic silicates become converted into clay, with separation of the alkali. This, absorbing carbonic acid from the atmosphere, would find its way to the sea, where, having first precipitated from its highly heated waters various metallic bases then held in solution, it would decompose the chlorid of calcium, giving rise to chlorid of sodium on the one hand, and to carbonate of lime on the other. In this way we obtain a notion of the processes by which from a primitive fused mass may be generated the silicious, calcareous and argillaceous rocks which make up the greater part of the earth's crust; and we also understand the source of the salts of the ocean."*

* Canadian Journal, May, 1859, 201, and Silliman's Journal [2], xxv, 102; also Comptes Rendus, June 9th, 1862, and Can. Naturalist, vii, 202.

§ 82. A further development of this view would lead us too far for the scope of this paper. It will however be seen that the first precipitates from the ocean would contain most of the metals, and that in the subsequent re-solution and deposition of these precipitates is to be found an explanation of the origin of metalliferous deposits, and of their distribution in various formations; either as integral parts of the strata, or as deposits in veins, the former channels of mineral springs. In an essay on American Geology, published in Silliman's Journal in 1861 [2], xxxi, 405, I have already sketched the outlines of what I conceive to be the true theory of metalliferous deposits, a subject to which it is proposed soon to return.—*Silliman's Journal*.

Montreal, July 4, 1865.

NATURAL HISTORY SOCIETY.

MONTHLY MEETINGS.

The ordinary monthly meeting of the Society was held on Monday evening, March 27th, the President, Principal Dawson, in the chair.

THE MUSEUM.

A donation of a collection of Canadian and Prince Edward Island insects from Mr. Horace L. Smith, was announced.

NEW MEMBERS.

Major Healy, Lieut. Boyle, and Messrs. Wm. Gunn and H. Rose, were elected ordinary members; and Com. Fortin a corresponding member.

PROCEEDINGS.

Prof. Eaton's paper on the genus *Woodsia* was read by the Secretary.

The President read a paper entitled "Notes on the Post-Pliocene Deposits at Rivière du Loup and Tadousac."

The Corresponding Secretary read an abstract of a paper entitled "Notes on the Trees and Shrubs of Canada," presented to the Society by the Hon. William Sheppard of Fairymeade, C. E.

The ordinary monthly meeting of the Society was held on Monday evening, April 24th, the President in the chair. Various donations to the library and museum were announced.

NEW MEMBERS.

Messrs. James Ewan, Wm. Muir, and J. A. Harte were elected ordinary members.

PROCEEDINGS.

Dr. Hunt read an abstract of a paper entitled "Contributions to the Chemistry of Natural Waters." Dr. Hunt also read an abstract of a paper on "The Extraction of Copper from its Ores in the Humid Way, by Thomas Macfarlane."

ANNUAL MEETING.

The annual meeting of the Society was held at its rooms on the evening of May 18th, the President, Principal Dawson, in the chair. Mr. Whiteaves, the Recording Secretary, read the minutes of the last annual meeting; after which the usual annual address by the President was delivered, as follows:—

THE PRESIDENT'S ADDRESS.

GENTLEMEN:—In the midst of the many exciting occurrences of the past year, we have reason for thankfulness and mutual congratulation that we have been enabled to pursue in peace our unobtrusive work, and that we have to record the past as one of the most successful years of this Society. More than twenty original papers on various departments of Natural History have been contributed, the greater part of which have been published in our Journal. Our course of Somerville Lectures and our Annual Conversazione have been eminently successful. Large additions have been made to our Museum, and much progress has been made in its arrangement. An Entomological club has been established in connection with the Society, and arrangements have been made for retaining for another term of two years the services of our efficient scientific curator, Mr. Whiteaves.

In Geology many important communications have been received. Among these I may particularly mention, in the first place, several papers by Dr. Hunt on Canadian lithology, on the silicification of fossils, on mineral waters and on the economical uses of peat. While all of these are of great value, I may direct particular attention to the very remarkable facts stated in the paper on mineral waters, in relation to the saline springs so abundant in this country, when regarded as affording evidence of the composition of that primeval ocean in which our Silurian beds were

deposited. As treated by Dr. Hunt, mineral springs cease to be merely objects of curiosity or for medicinal use, but acquire great geological interest, as indications of conditions of the ocean which have long since passed away, but which may have had an important influence on animal life and mineral accumulation in the paleozoic period; and also as illustrations of the causes of chemical change now in action in the crust of the earth.

The remarkable discovery by Mr. Billings of locomotive organs probably of the nature of swimming feet, in *Asaphus platycephalus*, read before the Society, but not yet published, deserves to be reckoned as one of the most important facts developed in connection with Canadian Geology in the past year. As an addition to this discovery, I may place the view which I presented to this Society, in a paper on the fossils known as *Rusophycus*, that these are in reality casts of burrows of trilobites, and entitled to the name *Rusichnites*.

In my address of last year I dwelt at some length on the question of the mode of formation of the boulder clay, and on the alleged action of glaciers in the post-pliocene period; and stated my reasons for the belief that floating ice was the agent in the striation of rock surfaces, and the transport of boulders in Canada; and that our lake basins had been eroded by the slow action of cold ocean currents. I have since followed up this subject, and in a paper on the post-pliocene deposits of Rivière du Loup, have endeavored to show the true marine character of the boulder clay of that locality, so rich in fossil shells of the post-tertiary period. I have also obtained facts which prove conclusively that the boulder clay of Montreal and its vicinity could not possibly have been sub-aerial, and that throughout Eastern Canada this deposit does not form a continuous sheet, but rather a series of old sea margins extending from an elevation of two or three hundred feet above the sea to the present sea level, and in time from the newer Pliocene period to the present day.

Lastly, under the head of Geology, but passing from the latest formations to the far distant dawn of organic life on our planet, our last number contains the re-publication of papers by Sir W. Logan, Dr. Carpenter, Dr. Hunt, and myself, on *Eozoon Canadense*, shewing that the views which I illustrated here a year ago, of the character of that remarkable fossil, have been fully confirmed by the greatest living authority on the group of animals to which the specimens were assigned, and that this great discovery has

been accepted as an unquestioned fact by all the leading minds in Geology.

Before leaving this part of our work, it is proper to state that the utility of our collection to students of Geology and Mineralogy has been much increased by the arrangement and display of our specimens of fossils, rocks and minerals, through the exertions of Mr. Whiteaves, aided by other members of the Society.

Among the numerous papers received on Zoölogy, Botany and Physical Geography, I may, without attempting any detailed notices, mention those of Mr. Jones on Ocean Drift, and on the fishes of Nova Scotia, communicated to our Journal by the Natural History Society of New Brunswick; of Mr. J. G. Bowles on *Pieris rapæ*; of Dr. Bowerbank on Canadian Sponges; of Prof. Brunet on the Travels of Michaux; of Prof. Lawson, Prof. Eaton, and Mr. McCord on Canadian Ferns; of Mr. Drummond on the Geographical Botany of Canada; of Hon. Mr. Sheppard on Canadian Timber trees; of Mr. Vennor on the Night Heron; of Mr. Whiteaves on Canadian Mammals; of Mr. Ritchie on the structure of Insects; and lists of plants of various localities in Canada contributed by Dr. Thomas, Mr. Drummond, Mr. Macoun, and other botanists. We owe also to the gentlemen of the Entomological club our cordial thanks for the generous donations which have filled our cabinet of insects with one of the most valuable collections of entomological specimens as yet accumulated in this city.

It is proper, on this occasion, to congratulate the Society on the completion of the first series of its Journal, the Canadian Naturalist, and on the commencement of the second volume of a new and improved series. The inception of the Canadian Naturalist is due to our colleague Mr. Billings, the palæontologist of the Canadian Survey; and the first volume was ably sustained by his unaided exertions. Adopted by the Natural History Society in 1857, it has now entered on its tenth year of publication, and contains in the volume already published a mass of information on the Natural History of British America, indispensable to every student of the subject. It has established its reputation wherever science is cultivated, and is now a recognized medium of communication between Naturalists in Canada and in foreign countries. It is only to be regretted, both for the sake of the interests of science and of the publishers of the work, who have heretofore issued it without any expense to the Society or any public aid, that it should not be more

extensively circulated. When we consider the difficulties experienced by scientific periodicals both in Britain and the United States, it is not surprising that a scientific journal in Canada should be slenderly supported. Still I think that, if the value of the articles contained in the *Naturalist*, and the importance of sustaining it, were properly understood, its subscription list would be largely increased. I earnestly commend this matter to the attention of members of the Society. It will be proposed in connection with this, in the Report of the Council, that a new class of members should be created in connection with the Society, namely, non-resident ordinary members, who should pay a subscription equivalent to that for the *Naturalist*, and should enjoy the advantages of the meetings and museum of the Society, during any visits they might make to the city. In this way I have no doubt that something might be done toward the introduction of a taste for Natural History, as well as toward the extension of the circulation of the *Naturalist*. It is to be hoped that these subjects will receive the early attention of the officers of the Society.

In conclusion, gentlemen, allow me to say that in cultivating here the amenities of science, and directing our attention and that of others to the works of God, we are in our humble way doing something for the welfare of this country. We are seeking to mingle the pursuit of merely utilitarian objects in the development of the resources of this country, with higher and more philosophical conceptions of nature. In the midst of many perturbed social and political elements, we are studying things that make for peace, and which are for the common benefit of all. While we are so constantly drawing closer the links of connection between ourselves and kindred institutions in other parts of the great empire to which it is our happiness to belong; and while, in common I believe with all scientific men and educators in British America, we feel that it is above all things desirable that still more intimate and mutually helpful relations should be established with the good heart of that empire, so that the political, social, and scientific power of Great Britain may be more strongly felt in these colonies, we can at the same time extend the most earnest sympathy and lively appreciation to the labors of scientific men in other lands, and can more especially ally ourselves in the closest manner with our numerous and able fellow-workers in the United States, who have always been so ready to recognise in our case that bond of brotherhood which should unite all the cultivators of science in every country.

In now resigning the office with which, contrary to my own desire, you have honored me twice in succession, I have only to express my regret that the pressure of other duties has prevented me from devoting more time to the interests of this Society, and my earnest wish that its prosperity in the past, and more especially since it entered on an enlarged career of usefulness in its new building, may prove an earnest of still greater success in the future.

REPORT OF THE COUNCIL.

The Chairman of the Council, Mr. Rimmer, then submitted the following Report.

Your Council beg to offer the following report of the proceedings of the past year. They regret to say that even the Society has not been quite free from the effects of the general commercial depression. The number of new members is fourteen, but on the other hand there have been many resignations. The list of members has not been revised for some years, and on careful scrutiny several names have been removed, many of whom have long ceased to belong to the Society.

The debt upon the building is still \$2400, bearing interest. The number of ordinary members is about 220, which should procure an income of about \$880; and two new life-members, Messrs. H. Fraser and John Molson, have been added during the year. This sum is, of course, exclusive of the government grant, which has not been received so far; but your Council have every reason to believe it will be when Parliament meets. We are again indebted to our treasurer Mr. Ferrier, for the liberality with which he has come forward and advanced money to liquidate the more pressing claims. The Society owes him now \$190, and the other claims against it are about \$300 for current expenses. Mr. Ferrier, by a system of cash payment for advertising, printing, and other items, has been able to reduce the expenditure from \$2100 to \$1700. The price charged for the use of the lecture-room has been reduced to \$6, and for the library to \$2 per evening.

Your Council would suggest, as a means of improving the income of the Society, that a new class of members might be introduced, viz. non-resident paying members, who might have all the advantages of the Society when they visit the city; and as they cannot attend our meetings, a copy of the *Naturalist* might be sent to their address. This would also give us the advantage of

being in constant communication with the residents of country places, from whom specimens of interest to the Society might be procured.

PUBLIC LECTURES.

The Somerville lectures this year have been extremely interesting; their subjects were as follows:

February 16th, 1865. On the Oldest Fossil known, and its living representatives: by Principal Dawson, LL.D., F.R.S.

March 2nd, 1865. On the Occurrence of Metals in Nature: by Dr. T. Sterry Hunt, F.R.S.

March 9th, 1865. Shells, considered from a popular and a literary point of view: by J. F. Whiteaves, F.G.S.

March 16th, 1865. On Ferns: by D. R. McCord, B.A.

March 21st, 1865. On Certain Chemical Manufactures which might be advantageously introduced and carried on in Canada: by Prof. Bell, F.G.S.

March 28th, 1865. On Combustion, illustrated with experiments: by Dr. Girdwood.

CONVERSAZIONE.

The Annual Conversazione of the Society was held on the evening of February 21st, and was unusually successful, upwards of 400 persons being present. [A report of this meeting will be found on page 75.]

MISCELLANEOUS.

It is a matter of congratulation that we have secured the services of Mr. Whiteaves for two years longer, commencing from the first of April, 1865, at a salary of \$400 per annum; and for this sum he undertakes to conduct the correspondence, to act as sub-Librarian, and to edit the *Naturalist* if necessary.

Mr. Whiteaves will give, in his capacity of curator and sub-librarian, an account of the alterations in and additions to the museum and library. Your Council respectfully urge upon their successors the desirability of increasing the membership as far as possible. There are so many advantages that we can offer to the public, and such facilities afforded for studying Natural History in the city and its vicinity, that we believe the Society requires to be more generally known than it is at present. There are many inhabitants of Montreal who have never seen the Museum; and it might be worth while to consider how far it could be thrown open to the public on certain occasions, free of charge, as is done by kindred institutions in Great Britain.

They are also, in conclusion, glad to find that more enlightened views are prevalent with regard to the protection of small birds ; this is partly owing to the representations made by our Society, and in part to the efforts of the Fish and Game Protection Club, with whom we cannot too cordially co-operate.

REPORT OF THE SCIENTIFIC CURATOR.

The most important work of the past summer has been the formation of a good entomological collection. Nearly all the old Canadian specimens which had become injured, and faded by exposure, have been replaced by fresh examples. By the exertions of friends our local collections have more than doubled lately ; not only have we filled the twenty-six drawers of our cabinet, but we have four cases full over and above these. As much has been done in the way of naming and classifying our specimens as the present state of our knowledge of Canadian insects warrants. The Coleoptera and the diurnal Lepidoptera are for the most part named. Many of the nocturnal Lepidoptera, and most of the Hymenoptera, Diptera, Neuroptera, Orthoptera, and Hemiptera of this country have yet to be determined. It is hoped that with the assistance of the Entomological branch of our Society, some steps may be taken in this direction. The large and interesting collection of minerals contained in the Museum has occupied a considerable portion of my time. A number of cases that have not been opened for years, have been unpacked, and their contents carefully looked over. Several specimens that were missing in Dr. Holmes' collection, have been restored to their place, and labelled. Including these, and several specimens placed in this collection for the sake of comparison, the series now consists of upwards of 1400 specimens from various parts of the world, all of which are carefully labelled. A collection of Canadian rocks and minerals has been formed to illustrate the prominent features of the lithological part of Canadian geology. A number of new specimens has been procured, and about 200 rocks and minerals are now named and exhibited. Two packages were found to contain a series of the rocks, lavas, and other minerals of Vesuvius and its neighborhood, a collection of great interest, and containing many fine specimens. The labels attached to these were written in Italian, and often incorrectly spelled. Signor de Angelis, who has lived many years in the immediate neighborhood of Vesuvius, has kindly helped me to identify the exact localities of the specimens, and Dr. Hunt has determined

some of the more difficult minerals. The set consists of about 380 specimens, all of which are now labelled and exhibited. These two last collections, which have never been exposed to view until now, occupy one of the new cases which were got last winter. A number of miscellaneous minerals of interest have been labelled and placed temporarily in the case in the aquaria room. The number of specimens labelled is about 165. A great many duplicates and worthless specimens have been selected and put away. The number of specimens of rocks and minerals that are now named and exhibited in the museum may be approximately summed up as follows:

Dr. Holmes's Collection, with additions, over 1400 specimens.		
Canadian Rocks and Minerals.....	200	"
Rocks and Minerals of Vesuvius.....	370	"
Miscellaneous do.....	165	"

In all upwards of..... 2135 specimens.

Some 500 or 600 specimens remain without any localities; they are mostly duplicate examples, and are in some cases undetermined.

The second new case has been entirely devoted to our collection of fossils. The old series was totally unnamed and devoid of any attempt at arrangement. Many new specimens have been added during the past session. Dr. Dawson has contributed several Devonian, Carboniferous and Post Tertiary species, Prof. Dana some Carboniferous and Cretaceous forms; and during last summer I received several donations to this part of our collection from various friends in the United States. The local fossils of the neighborhood of Montreal I have collected in person: most of these will be found in the collection. To Mr. Billings I am indebted for the determination of the Silurian and Devonian species, and to Principal Dawson for the nomenclature of the Carboniferous fossils; those of the Mesozoic and Tertiary periods were determined by myself.

The following is an estimate of this branch of our Collection.

Lower Silurian.....	61	species.
Middle ".....	23	"
Upper ".....	1	"
Devonian.....	31	"
Carboniferous.....	57	"
Lias.....	21	"
Oolite.....	42	"
Cretaceous.....	30	"
Tertiary.....	12	"
Post Tertiary.....	36	"

In all about 314 species.

The Polyzoa or Bryozoa of the Gulf of the St. Lawrence have been determined by Principal Dawson, and may now be conveniently studied. The Annelida, from the same district, have also been classified and named. The synonyms of the Canadian species of reptiles and fishes have been studied, and printed labels have been attached to the specimens. A few of our foreign birds have been determined and labelled. During the past summer several additions have been made to our collection of shells and radiates: these have been named and incorporated with the general series. During the past winter the making arrangements for the Somerville course of lectures devolved upon me. These I have often reported from notes taken during the evening, and when this has not been the case, care has been taken that reliable abstracts should appear in the daily press. It is hoped that the series as a whole has not proved inferior in point of interest to those of past years.

During the month of April, 1865, I devoted some time to the library, having been appointed sub-librarian on the first of that month.

The Treasurer of the Society, Mr. Ferrier, then gave an account of the financial position of the Society, showing what had been its receipts and expenditure during the past session. The details will be found on another page.

It was moved by the Right Rev. the Lord Bishop, and unanimously resolved:

That the special thanks of the Society be voted to the President of the past session for his valuable services during that time.

A vote of thanks to the other officers of the past year, was also unanimously carried.

The following gentlemen were elected as officers of the Society for the coming session:

OFFICERS FOR 1865-6.

President.—C. Smallwood, M.D., LL.D., D.C.L.

Vice-Presidents.—Principal Dawson, LL.D., F.R.S.; Rev. A. De Sola, LL.D.; Sir W. E. Logan, LL.D., F.R.S.; Dr. T. Sterry Hunt, LL.D., F.R.S.; E. Billings, F.G.S.; The Right Rev. the Lord Bishop and Metropolitan; John Leeming; Rev. A. F. Kemp, M.A.; and W. H. A. Davies.

Treasurer.—Jas. Ferrier, Jun.

Cor. Secretary.—Prof. P. J. Darey, M.A.

Rec. Secretary.—J. F. Whiteaves, F.G.S.

Librarian.—Stanley C. Bagg.

Council.—J. H. Joseph; E. Murphy; A. Rimmer; L. A. H. Latour; A. S. Ritchie; C. Robb; D. A. P. Watt; G. Barnston; and John Molson.

Library Committee.—(These with the Librarian, were elected also a Membership Committee) D. Mackay; G. H. Frothingham; Rev. Dr. Wilkes; Peter Redpath; and John Molson.

Editing Committee of the Canadian Naturalist.—D. A. P. Watt, Acting Editor; Principal Dawson; Dr. T. Sterry Hunt; E. Billings; J. F. Whiteaves; and Prof. P. J. Darey.

THE CANADIAN NATURALIST.

The Canadian Naturalist is sent to the following Institutions and Societies, &c.:

CANADA, ETC.

University College.....	Toronto.
Canadian Institute.....	Toronto.
Board of Arts.....	Toronto.
Queen's University.....	Kingston.
McGill College.....	Montreal.
Laval University.....	Quebec.
Literary and Historical Society.....	Quebec.
Natural History Society.....	St. John's, N.B.
Nova Scotia Institute of Nat. Science....	Halifax, N.S.

UNITED STATES.

Natural History Society.....	Portland, Maine.
Harvard College.....	Cambridge, Mass.
Amherst College.....	Amherst, Mass.
Essex Institute.....	Salem, Mass.
Yale College.....	New Haven, Conn.
Silliman's Journal,..	New Haven, Conn.
Lyceum of Natural History.....	New York.
Natural History Society.....	Boston, Mass.
State Library.....	Albany, New York.
Academy of Natural Sciences.....	Philadelphia, Penn.
Franklin Institute.....	Philadelphia, Penn.
Smithsonian Institution.....	Washington, D.C.

GREAT BRITAIN.

Geological Society.....	London.
Linnæan Society.....	London.
Royal Society,	London.
British Museum Library.....	London.
Society of Arts.....	London.
Geological Survey of Great Britain.....	London.
The Geological Magazine.....	London.
Technologist.....	London.

Quarterly Journal of Science,.....London.
 Popular Science Review,.....London.
 Naturalists' Field Club,.....Newcastle-upon-Tyne.
 Bodleian Library,.....Oxford.
 University Library,.....Cambridge.
 Literary and Philosophical Society,.....Manchester.
 University Library,.....Edinburgh.
 University College,.....Glasgow.
 Royal Geological Society,.....Dublin.

CONTINENT OF EUROPE.

Société Géologique de France,.....Paris, France.
 L'Académie des Sciences.....Dijon, France.
 Imper. Geological Institute,.....Vienna, Austria.
 Deutsches Geolog. Gesellschaft,.....Berlin, Prussia.
 University Library,.....Bonn, Prussia.
 Société Impériale des Naturalistes,Moscow, Russia.
 Konigl. Bayerischen Akademie der Wis-
 senschaften.....Munich, Bavaria.
 Academy of Sciences,.....Stockholm, Sweden.
 Christiana University,.....Christiana, Norway.
 Royal Library.....Copenhagen, Denmark.
 Bibliothèque Imperiale.....St. Petersburg, Russia.
 Batavian Academy,.....Leyden, Holland.
 Freiberg Royal Academy,.....Freiberg, Saxony.
 Nederlandisch Metereol. Jaarboek,.....Utrecht.

MONTHLY MEETING.

This Society held its last meeting for the session, 1864-65, on Monday evening May 29. The chair was occupied by Dr. Smallwood, the newly-elected President. After the transaction of the usual routine business, the following donations were announced.

TO THE MUSEUM.

From Mr. H. Leggett,—A series of precious stones, consisting of thirty-six specimens, including four rubies (uneut) from the East Indies, one sapphire from Ceylon, two aquamarines, four chrysoprases, three turquoises, a fine *cat's eye* from Ceylon amethysts, heliotropes, agates, &c., &c.

From Mr. D. McKay,—Specimen of the bullfrog (*Rana pipiens* Linn.)

From Mr. C. Foley—The Night heron (*Nyctiardea Gardeni* Baird); and an example of the American crow (*Corvus Americanus* Audubon).

From Mr. W. Hunter—A stuffed specimen of each of the following birds: The swamp sparrow, male (*Melospiza palustris* Baird); the Nashville warbler, female (*Helminthophaga ruficapilla* Baird); and a male bay-winged bunting, (*Poocetes gramineus* Baird)—all shot on Montreal mountain.

From Mr. Dunn—A jumping mouse, (*Jaculus Hudsonicus* Zimmerman).

THE NATURAL HISTORY SOCIETY OF MONTREAL IN ACCOUNT WITH JAMES FERRIER, JUN., TREASURER.

Dr.

Cr.

RECAPITULATION.		RECAPITULATION.	
1864.		1865.	
May 1.		May 1.	
To cash balance due Treasurer, May 1, 1864.....	\$ 15 43	By Cash, Government Grant	\$750 00
1865.		“ Members' yearly subscriptions.	301 00
May 1.		“ Life member's subscription, H. Fraser, Esq.	50 00
To Cash paid, Printing.....	309 38	“ Museum entrance fees.....	36 00
“ Furniture, cases, &c.....	70 00	“ Rent of Lecture Room.....	26 00
“ Sundry petty charges, repairs, &c....	51 65	“ Donation from Captain Serocold,.....	5 00
“ P. O. accts.....	12 90	“ Proceeds Conversazione.....	66 05
“ J. F. Whiteaves, salary.....	350 00	“ Balance due Treasurer.....	190 83
“ W. Hunter, salary.....	200 00		
“ W. McCormick, commissions.....	34 30		
“ Wood and coals.....	165 49		
“ Gas accounts.....	21 08		
“ Water “.....	40 65		
“ City taxes.....	40 00		
“ Insurance.....	34 00		
“ Interest.....	80 00		
	<u>\$1424 88</u>		<u>\$1424 88</u>

JAMES FERRIER, JUN., Treasurer N. H. S.

STATEMENT OF LIABILITIES OF THE NATURAL HISTORY SOCIETY, MAY 1ST, 1865.

Open Accounts.....	\$ 303 38
Mortgage on Society's Building held by Scottish Provincial Insurance Co.....	2000 00
“ in favor of William Watson, Esq.....	400 00—\$2763 38

PROCEEDINGS.

ON THE FOSSILS OF THE TRENTON LIMESTONE OF THE
ISLAND OF MONTREAL.

By J. F. WHITEAVES, F.G.S., &c.

This paper is offered partly as a compilation of the results obtained by other observers, and is partly derived from original investigation. It is thought desirable to place upon record all that is known with any degree of certainty respecting the fossils of the Trenton limestone proper—exclusive of the Black River Group—so far as these rocks have been explored on the island of Montreal. The zone and locality that I have examined with most care is the upper part of the formation, as it occurs between the villages of St. Jean Baptiste and St. Michel. In this district fourteen species have occurred to me, which, so far as I am aware, have not yet been recorded as occurring on the island, two of which (*Atrypa deflecta* Hall, and *Holopœa symmetrica* Hall), have not previously been detected in Canada. In addition to this, I have obtained one Cystidean (?) new to science, two new bryozoa (one the type of a new genus), a new brachiopod (of the *Orbicula* group), and a new species of *Otenodonta*. The list of fossils, however, must be looked upon only as a result of the commencement of an investigation which has yet to be carried out. To my friend, Mr. Billings, the Palæontologist of the Geological Survey of Canada, I am indebted for much valuable assistance in the determination of critical species. With the exception of *Strophomena deltoidea*, these fossils may perhaps be considered characteristic of the upper zone of the formation.

List of Fossils procured from the Trenton limestone proper, of the island of Montreal :

ZOOPHITA.

Stenopora fibrosa, Goldfuss.

“ *petropolitana*, Pander.

CRINOIDÆ.

Dendrocrinus acutidactylus, Billings.

“ *proboscidiatus*, “

“ *cylindricus*, “

Heterocrinus Canadensis, “

“ *tenuis*, “

Rhodocrinus pyriformis, “ (columns only).

Cleioocrinus grandis, “

CYSTIDÆ.

Pleurocystites squamosus, Billings.

“ *exornatus*, “

Glyptocystites Logani, Billings and var. gracilis.

" multiporus, Billings.

Also a specimen of a supposed new genus.

EDRIOASTERIDÆ.

Edrioaster Bigsbyi, Billings.

BRYOZOA.

Intricaria reticulata, Hall.

Ptilodictya acuta, "

Two new species, one probably of a new genus.

BRACHIOPODA.

Lingula quadrata, Eichwald.

" riciniformis, Hall.

" Progne, Billings.

" Phelomela, "

" Daphne, "

Discina Pelopœa, "

Trematis Montrealensis, Billings.

Leptæna sericea, Sowerby.

Strophomena alternata, Conrad.

" deltoidea, "

" tenuistriata, Sowerby.

Orthis testudinaria, Dalman.

" lynx, Eichwald.

" subquadrata, Hall.

" pectinella, Conrad.

" Eurydice, Billings.

Rhynchonella increbescens, Hall.

" recurvirostra, "

Camerella hemiplicata, Hall. (A. circulus? young of this?)

Atrypa deflecta, Hall? (New to Canada.)

LAMELLIBRANCHIATA.

Avicula Hermione, Billings.

Modiolopsis carinata, Conrad.

" faba, "

Ctenodonta dubia, Hall? (Perhaps the young of Tellinomya anatini-formis, Hall.)

Ctenodonta Astartœformis, Salter.

GASTEROPODA.

Holopea symmetrica, Hall. (New to Canada.)

" Nereis, Billings.

Ciclonema Montrealensis, Billings.

" Hageri, Billings.

Subulites subfusiformis, Hall.

Eculiomphalus Trentonensis, Conrad.

Trochonema umbilicata, Hall?

Pleurotomaria Americana, Billings.

Metoptoma Trentonensis, Billings.

PTEROPODA.

Conularia Trentonensis, Hall.

Bellerophon bilobatus, Low.

CEPHOLOPODA.

- Orthoceras proteiforme, Hall, and var. lineolatum.
 " strigatum, Hall.
 Cyrtoceras Juvenalis, Billings.
 " macrostomum, Hall? or a new species.

CRUSTACEA.

- Asaphus platycephalus, Stokes.
 Calymene Blumenbachii, Brongniart.
 Cheirurus pleurexanthemus, Green.
 Trinucleus concentricus, Eaton.

ENTOMOSTRACA.

- Leperditia Canadensis, var.—rare.

ANNELIDA.

- Serpulites dissolatus, Billings.
 (66 species).

REVIEW.

GEOLOGY OF NEW BRUNSWICK.

(Continued from page 239.)

One of the most important points in Prof. Bailey's Report, is the working out of the relations of the metamorphic rocks underlying the Devonian plant beds of St. Johns; and which, it now appears, constitute a series descending even to the horizon of the Laurentian. The following extracts relate to the Portland group, supposed to be Laurentian, the Coldbrook group in the horizon of the Huronian, and the Portland group, which yields Primordial fossils.

"PORTLAND GROUP.—*Age*.—It might readily be supposed that the extreme metamorphism exhibited by the rocks of the Portland group would be accepted as conclusive evidence of their great antiquity. Indeed the fact of such antiquity could scarcely have been doubted, were it not for the intimate association and almost entire conformability between the beds of this and the overlying groups, which have heretofore induced all the observers who have examined the district to link them in a single series. As the latter are unquestionably of Upper Devonian age, the beds of Portland were supposed to represent either a portion of the lower division of the same formation, or possibly the upper part of the Silurian. Dr. Dawson alone, while still adopting the latter view, called attention to the great resemblance between these rocks and those of the great

Laurentian series of Canada. It is with much gratification that we are now enabled to confirm, with a good degree of certainty, this opinion of their antiquity and geological position.

“The facts upon which this decision is based are chiefly these : first, the great metamorphism of the series, and secondly, the position which it holds with reference to the overlying formations. It will be impossible clearly to explain the latter without anticipating the description of the groups which are to follow, but it will be sufficient here to say that one of these groups, that of Saint John, formerly supposed to be connected with the Devonian series, has been shown, upon the evidence, of its fossils to be undoubtedly Primordial, or to be the equivalent of the Potsdam rocks of other portions of North America—rocks at the very base of the Lower Silurian series. Were the rocks of Portland simply underneath the fossil-bearing beds of the Saint John group, we should still be obliged to regard them as Azoic ; but, as will hereafter be shown, they are really separated from the latter by the entire mass of the Coldbrook group, representing certainly not less than 7000 feet of stratified deposits, which must have been formed in the interval between the laying down of the Portland beds, and the shales and sandstones of Saint John.

“If then, as is probable, the Coldbrook group is the partial representative of the Huronian beds of Canada, we cannot hesitate in assigning the subjacent syenites and limestones of Portland to the great and still more ancient Laurentian series, a group heretofore supposed to be unrepresented in this portion of the continent.

“In corroboration of this view, we have only to call attention to the great similarity of the two formations in their mineral composition, and their extreme metamorphism. Without entering into minute details, (for the study of which the reader is referred to the Reports of Sir William Logan on the Geology of Canada,) it may be sufficient here to say that this resemblance is apparent in the succession of stratified deposits, consisting in both, principally of gneiss, quartzite, limestone, anorthosite (?) and occasional bands of mica-schist, together with syenite, and rocks which can with difficulty be distinguished from intrusive granites. Both hold beds of graphite, sulphurets of the different metals, serpentine (in connection with the calcareous beds, producing ophiolites), as well as many simple minerals, such as hornblende, muscovite, pyralolite (?) tourmaline, feldspar, and others. The abundance of magnesian silicates in the Portland rocks is also remarkable, as observed by Mr. Matthew, and suggests the possibility that the limestone

may in part be dolomitic like the similar calcareous beds of the Laurentian.

"COLDBROOK GROUP.—*Characters*.—It has been stated that the Coldbrook group consists of two members, an upper, soft, red, and of aqueous origin, and a lower, in which the rock is chiefly a hard greenish-grey compact slate. There is but little variation in the characters of these members throughout their entire extent.

"In the neighbourhood of Saint John the development of the group is of too limited character to serve for illustration. Widening however, to the eastward, it is well exposed along the valley of the Coldbrook, and the following succession has been observed by Mr. Matthew :—

1. Hard greenish-gray slate, stratification very obscure.
 2. Conglomerate, with bright red slaty paste.
 3. Grey conglomerate.
 4. Coarse reddish grit, and conglomerate with purple sandstone.
- Apparent thickness of the whole, 5000 feet.

"In tracing the group to the eastward, along the northern side of the Loch Lomond Lakes, two sections have been made across the lower member of the series, the first extending from "the Thoroughfare" between the first and second lakes, to the Golden Grove settlement, the second from the latter to the third lake, thus recrossing the same ridge.

"Along the line of the first section, the rocks of the group differ from their development westward, chiefly in the occurrence of a middle band of sandstone and shale, resting upon a thick succession of porphyritic and amygdaloidal traps, associated with bands of ferruginous and white feldspathic quartzites. Near the lower part of Golden Grove, the base of the Coldbrook group is represented by the occurrence of heavy beds of dark-grey sandstones and coarse quartzose conglomerates, the latter much faulted and injected.

"The great thickening of the Coldbrook beds in this vicinity is probably, as suggested by Mr. Matthew, the cause of the decided easterly trend noticeable in the upper member of the present group, as well as in the overlying deposits.

"Along the second section referred to, no facts additional to those now given were observed, with the exception that a portion of the series near Brawly Lake has been exposed by an extensive slide, and now projects in wild and lofty overhanging cliffs above the ruin at its base.

"It has been stated that rocks apparently forming a portion of the upper member of the group now under consideration, occur

along the southern side of the first Loch Lomond Lake. They consist of purplish-red trappeau and quartzose sandstone, but are not well exposed. Although probably belonging, as above stated, it is possible that these rocks may represent the upper member of the Blomsbury group, hereafter to be described.

“Southward of the above, along the line of Ratcliffe’s Millstream, the exposures are more clearly visible, and the Coldbrook rocks may be again distinctly recognized. Nominally underlying the Saint John group, which is a newer series, they here lie above the latter, both formations having been reversed by a folding of the strata. They consist at this place of purple sandstone, greenish-grey, red and purple sandy shales. To the eastward the same member appears crossing Handford’s and Harding’s Brooks, on the old road from Quaco to Sussex.

“Returning for a moment to the neighborhood of Loch Lomond, we have next to consider the rocks of this group, occurring to the southward of the fault and downthrow at the Negro settlement. Near the last named place, and resting upon a ridge of eruptive syenite, Mr. Matthew has observed a series of compact slaty traps, with beds and dykes of greenstone, these in turn being overlaid by a broad band of white and pink felspathic and silicious slates. Upon them again repose a series of heavy ash-slates and amygdaloidal traps, forming the northern side of the valley of Black River. On the southern side of the latter, beds of the Saint John group appear.

“In the sequence of volcanic sediments detailed above, a close resemblance is apparent to the similar succession already given on the north side of Loch Lomond. The same sequence is also apparent along the old road to Quaco, being especially noticeable in the occurrence in each of fine pink felspathic quartzites, succeeding bluish, pink and grey porphyritic slates.

PRIMORDIAL FOSSILS.

“ST. JOHN GROUP.—*Age*.—The question of age in the Saint John series, is one of great importance, throwing light, as it does, upon the origin of all the associated groups. It has been our fortune to discover facts which leave this question no longer doubtful.

“It has already been remarked, when describing the character of this series as developed in the city of Saint John, that the remains of a *lingula*, an animal related to our modern shell-fish, had been found to characterize in considerable numbers some of the sandy beds, but that they were too imperfectly preserved, and too indeci-

sive in their character to throw any positive light upon the age of the rocks which hold them. The other markings before mentioned, such as worm-burrows, shrinkage-cracks, and rain-drop impressions, although they furnished conclusive evidence as to the physical conditions under which the beds were formed, did not serve to remove the obscurity which enveloped the discussion of their age.

“Subsequently, during an examination of the valley of the Coldbrook by Mr. Matthew and his brother, organic remains were observed of a more decided character. These latter consisted, besides some obscure relics of a small orthoceratite, and numerous trilobites of two or three species, but these were so excessively distorted that no satisfactory conclusions could be based upon their study. Until the present summer, therefore, the age of this great series, although vaguely surmised, remained a subject of discussion and doubt. The discovery of finely-preserved Trilobites and Brachiopods at Ratcliffe's stream, and in the valley of the Coldbrook, has now removed this doubt, and left no uncertainty as to the age and origin of the group which holds them. We regard this discovery as among the most interesting and valuable results of our summer's labour.

“That the discussion of this question might have the careful and attentive study which its importance demanded, the fossils above referred to were placed in the hands of Mr. Hartt, who, as will be seen below, has enjoyed peculiar facilities for their determination and comparison. It had been hoped that the entire results of that gentleman's labours might have been embodied in the present Report, but the want of sufficient leisure for their complete analysis, has prevented this from being accomplished. The following notice is, however, introduced as preliminary to a more detailed description to be given hereafter :

Preliminary Notice of a Fauna of the Primordial Period in the vicinity of St. John, N. B.

By C. FRED. HARTT, A.M.

“My examination of the fossils collected last August, from the Saint John group, at Ratcliffe's millstream, by Prof. Bailey, Mr. Geo. Matthew, and myself, and of a collection made from the same group at Coldbrook, in 1863, by Messrs Geo. and C. R. Matthew, is not yet sufficiently complete to enable me to give an extended description of them here. I shall therefore limit myself, at present, to a notice of the genera, and of the aid they afford in the determination of the geological position of the Saint John group,

leaving the descriptions and figures of the species to be given in a paper which will appear in the Appendix to this Report.

“ The fossils as yet known to occur in the rocks of the Saint John group, are principally Trilobites, which are represented by quite a large number of species, and Brachiopoda, which last are of more rare occurrence. All these fossils are preserved as casts or impressions, the tests of the crustacea and the shells of the Brachiopoda being usually transformed into oxide of iron.

“ All the specimens have suffered more or less from distortion through pressure and the metamorphosis to which the rocks enclosing them have been subjected. The Trilobites occur also as detached fragments, so that their accurate determination is not easy, and more material is required in order satisfactorily to figure and describe all the species.

“ Representatives of four genera of Trilobites have been obtained thus far from the Saint John rocks, viz :—*Paradoxides*, *Conocephalites*, *Agnostus*, and a new genus (?) allied to *Conocephalites*.

“ The number of species in each genus has not yet been satisfactorily made out; but of *Paradoxides* there are at least five, of *Conocephalites* seven, and of *Agnostus* and the new genus each one.

“ All the species appear to be new. One of the *Paradoxides* bears a close resemblance to *P. rugulosus*, Corda, from the Etage C of Barrande, in Bohemia, and one of the *Conocephalites* is allied to *C. coronatus*, Barrande, from the same fauna and horizon, though neither is identical with the European species.

“ There are six species of Brachiopoda, belonging to the genera *Orthisina*, *Discina*, *Obolella*, and *Lingula*. I have not been able to identify any of the forms with described species.

“ Though all the species from the Saint John group are apparently new, yet the occurrence of *Paradoxides* and *Conocephalites*, genera confined entirely to the so-called Primordial fauna of Barrande, and everywhere characteristic of it, together with the strong likeness borne by the Saint John species, in their facies, to those of the same genera of the faunæ of the Primordial in Europe and America, enable us unhesitatingly to assign to the Saint John group, or at least to that lower part of it which has afforded Trilobites, a geological position equivalent to Barrande's Etage C, or to the Potsdam proper of America.

“ As Agassiz has shown, Barrande uses the word fauna, in his term primordial fauna, in a sense equivalent to epoch or horizon, A fauna is strictly a collection of animals confined within a limited geographical area. The terms ‘primordial fauna,’ ‘second

fauna,' are used with propriety when applied to the groups of fossils characterizing the Etages C and D in Bohemia; but these terms, unless limited, should not be extended to equivalent groups of the same age, but forming distinct faunæ, in other parts of the world, for such a double sense is incompatible with that precision which should mark the use of scientific terms. Primordial zone is objectionable; if the term Primordial is used, and it is very appropriate, it would be much better to say Primordial Period, period as used by Agassiz, being equivalent to Barrande's *etage*.

"The lower part of the Saint John group, at Coldbrook, has been divided by Mr. Matthew on lithological grounds, into three bands, viz:—

No. 1. The lower arenaceous band, with no determinable fossils, and constituting passage beds from the Coldbrook group.

No. 2. Argillaceous shales, rich in fossils, *Paradoxides*, *Orthisina* (?), *Conocephalites*, *Obolella*.

No. 3. Carbonaceous shales, full of fossils, *Paradoxides*, *Conocephalites*, *Orthisina*, *Discina*, &c., all much distorted.

"I have not observed No 2, at Ratcliffe's millstream. No. 3, at Coldbrook, corresponds exactly, in its fossil remains, to the bed at the millstream, from which the Trilobites, &c., were obtained. Nearly, if not all, the fossils I have seen from No. 2, at Coldbrook, are entirely distinct from those of No. 3 of the same locality and the Millstream; but more material is required to establish the claim of these two beds to be considered as being characterized by distinct successive faunæ. At all events, all the species from both beds are different from those elsewhere occurring, and for at least bed No. 3, we have in the vicinity of Saint John a distinct fauna of the Primordial period.

"Through the kindness of Prof. Agassiz, under whose supervision my work is being done, and to whose suggestions I am largely indebted, I have been able to compare my specimens with the fine suite of Bohemian and other Primordial Trilobites in this Museum. The results of these comparisons I shall leave to be brought out in my forthcoming paper."

As might be expected, both reports contain much important information as to the carboniferous rocks of New Brunswick; but for this we must refer to the publications themselves, which should be on the shelves of every geologist.

Published, Montreal, September 20, 1865.

THE
CANADIAN NATURALIST.

SECOND SERIES.

MEETING OF THE BRITISH ASSOCIATION.

PRESIDENT'S ADDRESS: BY JOHN PHILLIPS, M.A., LL.D., F.R.S.*

Professor PHILLIPS having taken the chair, was received with loud applause. He said—

Assembled for the third time in this busy centre of industrious England, amid the roar of engines and the clang of hammers, where the strongest powers of nature are trained to work in the fairy chains of art, how softly falls upon the ear the accent of science, the friend of that art, and the guide of that industry! Here, where Priestley analysed the air, and Watt obtained the mastery over steam, it well becomes the students of nature to gather round the standard which they carried so far into the fields of knowledge. And when, on other occasions, we meet in quiet colleges and academic halls, how gladly welcome is the union of fresh discoveries and new inventions with the solid and venerable truths which are there treasured and taught. Long may such union last; the fair alliance of cultivated thought and practical skill; for by it labor is dignified and science fertilised, and the condition of human society exalted!

Through this happy union of science and art, the young life of the British Association—one-third of a century—has been illustrated by discoveries and enriched by useful inventions in a degree never surpassed. How else could we have gained that knowledge

* Delivered in the Town Hall, Birmingham, September 6, 1865.

of the laws of nature which has added to the working strength of a thousand millions of men the mightier power of steam (*a*), extracted from the buried ruins of primeval forests, their treasured elements of heat and light and color, and brought under the control of the human finger, and converted into a messenger of man's gentlest thoughts, the dangerous mystery of the lighting (*b*)?

How many questions have we asked—not always in vain—regarding the constitution of the earth, its history as a planet, its place in creation; now probing with sharpened eyes the peopled space around—peopled with a thousand times ten thousand stars; now floating above the clouds in colder and clearer air; now traversing the polar ice—the desert sand—the virgin forest—the unconquered mountain; now sounding the depths of the ocean, or diving into the dark places of the earth. Everywhere curiosity, everywhere discovery, everywhere enjoyment, everywhere some useful and therefore some worthy result. Life in every form, of every grade, in every stage; man in every clime and under all conditions; the life that now surrounds us, and that which has passed away;—these subjects of high contemplation have been examined often, if not always, in the spirit of that philosophy which is slowly raising, on a broad security of observed facts, sure inductions, and repeated experiments, the steady columns of the temple of physical truth.

Few of the great branches of the study of nature on which modern philosophy is intent were left unconsidered in the schools of Athens; hardly one of them was or indeed could be made the subject of accurate experiment. The precious instruments of exact research—the measures of time, and space, and force, and motion—are of very modern date. If, instead of the few lenses

(*a*) The quantity of coal dug in Great Britain, in the year 1864, appears by the returns of Mr. R. Hunt to have been 92,787,873 tons. This would yield, if employed in steam-engines of good construction, an amount of available force about equal to that of the whole human race. But in the combustion of coal not less than ten times this amount of force is actually set free—nine-tenths being at present unavailable, according to the statement of Sir. William Armstrong, in his address to the meeting at Newcastle, in 1863.

(*b*) The definite magnetic effect of an electrical current, was the discovery of Oersted in 1819: Cooke and Wheatstone's patent for an Electric Telegraph is dated in 1837; the first message across the Atlantic was delivered in 1858. *Tantæ molis erat.*

and mirrors, of which traces appear in Greek and Roman writers (c), there had been even the first Galilean or the smallest Newtonian telescope in the hands of Hipparchus, Eratosthenes, or Ptolemy, would it have been left to their remote successors to be still struggling with the elements of physical astronomy, and waiting with impatience till another quarter of a century shall have rolled away, and given us one more good chance of measuring the distance of the sun by the transit of Venus? Had such instruments as Wheatstone's chronoscope been invented, would it have been left to Foucault to condense into his own apartment an experimental proof of the velocity of light, and within a tract of thirty feet to determine the rate of its movement through all the vast planetary space of millions and thousands of millions of miles, more exactly than had been inferred by astronomers from observations of the satellites of Jupiter (d)? By this experiment the velocity of light appears to be less—sensibly less—than was previously admitted; and this conclusion is of the highest interest. For, as by assuming too long a radius for the orbit of Jupiter the calculated rate of light-movement was too great; so now, by employing the more exact rate and the same measures of time, we can correct the estimated distance of Jupiter and all the other planets from the sun. We have, in fact, a really independent measure of planetary space; and it concurs with observations of the parallax of Mars, in requiring a considerable reduction of the assumed diameters of the planetary paths. The distance of the earth from the sun must be reduced from above ninety-five to less than ninety-three millions of miles, and by this scale the other space measures of the solar

(c) The effect of lenses or globes of glass or crystal (*υαλος*) in collecting the solar rays to a point, are familiarly referred to by Aristophanes in the *Nubes*, 766; and the ornamental use of convex and concave reflectors is known by the curious discussions in the Fourth Book of Lucretius.

(d) Fizeau performed experiments on the velocity of light between Suresnes and the Butte Montmartre, by means of the oxyhydrogen light, reflected back in its own path. The space was 28,324 ft. Engl. Twice this distance was traversed in $\frac{1}{18,000}$ of a second = 167,528 geogr. miles in a second. From observations of Jupiter's satellites, Delambre inferred 167,976 miles, Struve 166,096. The experiment of M. Foucault gives 298,000,000 metres = 160,920 geogr. miles.

system, excepting the diameter of the earth and the distance and diameter of the moon, may be corrected (*e*).

The light and heat which are emitted from the sun reach the earth without great diminution by the absorptive action of the atmosphere; but the waste of heat from the surface of our planet through radiation into space is prevented, or rather lessened, by this same atmosphere. Many transparent bodies admit freely heat-rays derived from a source of high temperature, but stop the rays which emanate from bodies only slightly warmed. The atmosphere possesses this quality in a remarkable degree, and owes it to the presence of diffused water and vapor; a fact which Dr. Tyndall has placed in the clear light of complete and varied experiment (*f*). The application of this truth to the history of the earth and of the other planets is obvious. The vaporous atmosphere acts like warm clothing to the earth. By an augmented quantity of vapor dissolved, and water suspended in the air, the waste of surface-heat of the earth would be more impeded; the soil, the water, and the lower parts of the atmosphere would grow warmer; the climates would be more equalized; the general conditions more like what has been supposed to be the state of land, sea, and air during the geological period of the Coal-measures.

Such an augmentation of the watery constituents in the atmosphere would be a natural consequence of that greater flow of heat from the interior, which, by many geologists, mathematicians, and chemists, is supposed to have happened in the earlier periods of the history of the earth.

By the same considerations we may understand how the planet Mars, which receives not half so much heat from the sun (*g*) as

(*e*) Estimates of the earth's distance from the sun have varied much. Cassini and Flamsteed, using observations of the parallax of Mars, ascribe to it ten or eleven thousand diameters of the earth=79 or 89 millions of miles. Huyghens estimated it at twelve thousand=95 millions of miles. In 1745, Buffon reported it as the common opinion of astronomers at 30 millions of leagues (Fr.)=90 millions miles (Engl); but after the transit of Venus in 1769, he allowed 33 millions. Such was the effect of that now supposed erroneous experiment on the opinions of astronomers. (*Epoques de la Nature.*)

(*f*) Proc. of Roy. Soc. 1861. The Rumford Medal was adjudged to Dr. Tyndall in 1864.

(*g*) The proportion is about $\frac{1.00}{2.21}$ according to the received measure of the mean distance.

the earth does, may yet enjoy, as in fact it seems to enjoy, nearly a similar climate, with snows alternately gathering on one or the other of its poles, and spreading over large spaces around, but not, apparently beyond the latitude of 50 deg. or 40 deg.; the equatorial band of 50 deg. or 40 deg. north or south being always free from snow-masses bright enough and large enough to catch the eye of the observer. Mars may, therefore, be inhabited, and we may see in the present state of this inquiry reason to pause before refusing the probability of any life to Jupiter and even more distant planets.

The history of suns and planets is in truth the history of the effects of light and heat manifested in them, or emanating from them. Nothing in the universe escapes their influence; no part of space is too distant to be penetrated by their energy; no kind of matter is able to resist their transforming agency. Many if not all the special forces which act in the particles of matter are found to be reducible into the general form of heat; as this is convertible and practically is converted into proportionate measures of special energy. Under this comprehensive idea of convertibility of force, familiar to us now by the researches of Joule (*h*), the reasonings of Grove (*i*) and Helmholtz, and the theorems of Rankine (*k*), it has been attempted by Mayer, Waterston, and Thomson (*l*), to assign a cause for the maintenance of the heat-giving power of the sun in the appulse of showers of aerolites and small masses of matter, and the extinction of their motion on the surface of the luminary. By calculations of the same order, depending on the rate of radiation of heat into space, the past antiquity of the earth and the future duration of sunshine have been expressed in thousands or millions of centuries (*m*). In like manner the physical changes on the sun's disk, by which portions of his darkly heated

(*h*) Phil. Mag. 1843; Reports of the British Association, 1845; Trans. of the Royal Society, 1850.

(*i*) Grove on the Correlation of Physical Forces. 1846.

(*k*) Rankine, Trans. of the Royal Society of Edinburgh, 1850-51; Phil. Trans. 1854.

(*l*) Communication to the Royal Society of Edinburgh, 1854.

(*m*) Professor Thomson assigns to the sun's heat, supposing it to be maintained by the appulse of masses of matter, a limit of 300,000 years; and to the period of cooling of the earth from universal fusion to its actual state, 98,000,000 years. These are the lowest estimates sanctioned by any mathematician.

body become visible through the luminous photosphere, have been connected, if not distinctly as a cause, certainly as a coincident phenomenon, with particular magnetic disturbances on the surface of the earth; the solar spots and the magnetic deflections concurring in periods of maxima and minima of ten or eleven years duration. Thus even these aberrant phenomena become part of that amazing system of periodical variation which Sabine and his fellow-laborers, British, French, German, Russian, and American, have established by contemporaneous observation over a large part of the globe (*n*).

With every change in the aspect and position of the sun, with every alteration in the place and attitude of the moon, with every passing hour the magnetism of the earth submits to regular and calculable deviation. Through the substance of the ground, and across the world of waters, Nature, ever the beneficent guide to science, has conveyed her messages and executed her purposes, by the electric current, before the discovery of Oersted and the magical inventions of Wheatstone revealed the secret of her work.

Even radiant light in the language of the new philosophy is conceived of by Maxwell (*o*), as a form of electro-magnetic motion. And thus the imponderable, all-pervading powers, by which molecular energy is excited and exchanged, are gathered into the one idea of restless activity among the particles of matter :—

—æterno percita motu :

ever-moving and being moved, elements of a system of perpetual change in every part, and constant preservation of the whole.

What message comes to us with the light which springs from the distant stars, and shoots through the depths of space to fall upon the earth after tens, or hundreds, or thousands of years? It

(*n*) Among the interesting researches which have been undertaken on the subject of the spots, may be mentioned those of Wolfe (*Compte rendus*, 1859), who finds the number and periodicity of the spots to be dependent on the position of Venus, the Earth, Jupiter, and Saturn. Stewart has made a special study of the relation of the spots to the path of Venus (*Proc. of the Roy. Soc.* 1864); and Chacornac is now engaged in unfolding his conception of the spots as the visible effect of volcanic excitement. The peculiar features of the solar surface are under examination by these and other good observers, such as Dawes, Nasmyth, Secchi, Stone, Fletcher, and Lockyer.

(*o*) *Proc. of Roy. Soc.* 1864. The elder Herschel appears to have regarded the light of the sun and of the fixed stars as perhaps the effect of an electro-magnetic process—a perpetual aurora.

is a message from the very birthplace of light, and tells us what are the elementary substances which have influenced the refraction of the ray. Spectral analysis, that new and powerful instrument of chemical research for which we are indebted to Kirchhoff, has been taught by our countrymen to scrutinise not only planets and stars, but even to reveal the constitution of the nebulæ, those mysterious masses out of which it has been thought new suns and planets might be evolved—nursing mothers of the stars. For a time, indeed, the resolution of some nebulæ, by the giant mirror of Lord Rosse, afforded ground for opposing speculation of Herschel and the reasoning of Laplace, which required for their very starting-point the admission of the existence of thin gaseous expansions, with or without points or centres of incipient condensation, with or without marks of internal movement. The latest results, however, of spectral analysis of stars and nebulæ by Mr. Higgins and Professor W. A. Miller, have fairly restored the balance. The nebulæ are indeed found to have in some instances stellar points, but they are not stars; the whole resembles an enormous mass of luminous gas, with an interrupted spectrum of three lines, probably agreeing with nitrogen, hydrogen, and a substance at present unknown (*p*). Stars, tested by the same accurate hands, are found to have a constitution like that of our own sun, and, like it, to show the presence of several terrestrial elements, as sodium, magnesium, iron, and very often hydrogen. While in the moon and Venus no lines whatever are found due to an atmosphere, in Jupiter and Saturn, beside the lines which are identical with some produced in our own atmosphere, there is one in the red, which may be caused by the presence of some unknown gas or vapor. Mars is still more peculiar, and enough is ascertained to discountenance the notion of his redness being due to a peculiarity of the soil (*q*).

To aid researches into the condition of celestial bodies, the new powers of light, discovered by Niepce, Daguerre, and Talbot, have been employed by Bond, Draper, De la Rue, and other astronomers. To our countryman, in particular, belongs the honor of successful experiments on the rose-colored flames which extend from certain points of the sun's border during an eclipse; as well as of valuable contributions through the same agency to that enlarged survey of the physical aspect of the moon, which, since 1852,

(*p*) Proc. Roy. Soc. and Phil. Trans. 1864.

(*q*) Phil. Trans. 1864.

the Association has striven to promote. By another application of the same beautiful art, in connection with clock-work, the momentary changes of magnetic force and direction, the variations of temperature, the fluctuations of atmospheric pressure, the force of the wind, the fall of rain, the proportion of ozone in the air, are registered in our observatories; and thus the inventions of Ronalds and his successors have engaged the solar rays in measuring and comparing contemporaneous phenomena of the same order over large parts of the globe—phenomena some of which are occasioned by those very rays.

As we ascend above the earth, heat, moisture and magnetic force decrease, the velocity of wind augments, and the proportion of oxygen and nitrogen remains the same. The decrease of heat as we rise into the air is no new subject of enquiry, nor have the views respecting it been very limited or very accordant. Leslie considered it mathematically in relation to pressure; Humboldt gave the result of a large enquiry at points on the earth's surface, unequally elevated above the sea; and finally, Mr. Glaisher and Mr. Coxwell, during many balloon ascents to the zones of life-destroying cold, far above our mountain tops, have obtained innumerable data, in all seasons of the year, through a vast range of vertical height. The result is to show much more rapid decrease near the earth, much slower decrease at great elevations; thus agreeing in general with the view of Leslie, and yet throwing no discredit on the determinations of Humboldt, which do not refer to the free atmospheric ocean, but to the mere borders of it where it touches the earth, and is influenced thereby (*s*).

The proportion of carbonic acid gas in the atmosphere at great heights is not yet ascertained; it is not likely to be the same as that generally found near the earth; but its proportion may be more constant, since in those regions, it is exempt from the influence of the actions and reactions which are always in progress on the land and in the water, and do not necessarily compensate one another at every place and at every moment.

Other information bearing on the constitution of the atmosphere comes to us from the auroral beams and other meteoric lights known as shooting stars. For some of these objects not only appear at heights of ten, fifty, and 100 or more miles above the earth, but at the height of fifty miles it is on record that shooting stars

(*s*) Reports of the British Association for 1862, 1863, 1864.

or fire-balls have left waving trains of light, whose changes of form were in seeming accordance to varying pressure in the elevated and attenuated atmosphere. (*t*)

Researches of every kind have so enriched meteorology since our early friend, Professor J. Forbes printed his suggestive reports on that subject; and so great have been the benefits conferred on it by the electric telegraph, that at this moment in M. Leverrier's observatory at Paris, and the office so lately presided over by Admiral FitzRoy in London, the messages are arriving from all parts of Europe to declare the present weather, and furnish grounds for reasonable expectation of the next probable change. Hardly now within the seas of Europe can a cyclone begin its career of devastation, before the warning signal is raised in our seaports, to restrain the too confident sailor. The gentle spirit which employed this knowledge in the cause of humanity has passed away, leaving an example of unselfish devotion, in a work which must not fail through any lack of energy on the part of this Association, the Royal Society, or the Government. We must extend these researches and enlarge these benefits by the aid of the telegraph bringing the ends of the world together. Soon may that thread of communication unite the two great sections of the Anglo-Saxon race, and bring and return through the broad Atlantic the happy and mutual congratulations for peace restored and friendships renewed.

The possible combinations of force, by which, in the view we have been considering the characteristic force and special phenomena of solid, liquid, and gaseous matter are determined, may be innumerable. Practically, however, they appear to be limited, as natural products, to less than one thousand distinguishable compounds, and less than one hundred (*u*) elementary substances. Of these elements the most prevalent are few on the earth; as of gases, oxygen, hydrogen, nitrogen; of solids, silicon, calcium, magnesium, sodium, iron; and it is interesting to learn by analysis of the light of stars and planets, that these substances, or some of them, are found in most of the celestial objects yet examined, and that, except in one or two instances, no other substances have been traced

(*t*) This is the result of a careful discussion made by myself of observations on a meteor seen from Rouen to Yorkshire, and from Cornwall to Kent, Jan. 7, 1856.

(*u*) At the present moment the number of "elementary substances" is sixty-one.

therein. Even the wandering meteoric stones, which fall from their courses, and are examined on the earth, betray only well-known mineral elements, though in the manner in which these are combined, some differences appear, which, by chemical research and the aid of transparent sections, Professor Maskelyne and Mr. Sorby are engaged in studying and interpreting (*x*).

By the labors of Lavoisier and his contemporaries, chemistry acquired a fixed logic and an accurate nomenclature. Dalton and the great physicists of the early part of this century gave that law of definite combination by proportionate weights of the elements which is for chemistry what the law of gravitation is for celestial mechanics. A great expansion of the meaning of the atomic theory took place, when Mitscherlich announced his views of isomorphous, isomeric, and dimorphous bodies. For thus it came gradually to appear that particular forces resided in crystals in virtue of their structure, lay in certain directions, and exhibited definite physical effects, if the chemical elements, without being the same, were combined in similar proportions and aggregated into similar crystals. Some years later, ozone was discovered by Schönbein, and it concurred with a few other allotropic substances in reviving, among philosophic chemists, the enquiry as to the relative situation of the particles in a compound body, and the effects of such arrangements: an idea which had been expressed by Dalton in diagrams of atoms, and afterwards exercised the ingenuity of Exley, MacVicar, and others (*y*).

Everything connected with this view of the modification of physical properties by the arrangement of the particles—whether

(*x*) Professor Maskelyne has made a convenient classification of the large collection of meteorites in the British Museum, under the titles of "Aërolite or Meteoric Stone;" "Aërosiderite or Meteoric Iron;" and "Aërosiderolites," which includes the intervening varieties. Mr. Sorby, whose latest results are unpublished, but will be communicated to the Royal Society, is of opinion that the substance of meteorites has undergone changes due to physical conditions in some ancient period not now to be paralleled on our planet, or on the moon, but rather to be looked for only in the immediate neighborhood of the sun. Professor Haidinger has also made a special study of meteorites.

(*y*) Dalton, Chemistry, vol. i. 1808. A clear view of the simpler applications of Dalton's ideas is given by the illustrious author in Daubeny's Treatise on the Atomic Theory, 1850.

Exley, Nat. and Exp. Philosophy, 1829.

MacVicar, Reports of the British Association for 1855.

elementary or compound—is of the highest importance to mineralogy, a branch of study by no means so much in favor even with chemists as its own merits and its collateral bearings might justly deserve. Yet it is in a great measure by help of this branch of study that the opinions now current regarding metamorphism of rocks *in situ*, and the formation of mineral veins, must acquire that solid support and general consent which at present they do not possess. Crystals, indeed, whether regarded as to their origin in nature, their fabrication by art, or their action on the rays of light, the waves of heat and sound, and the distribution of electricity, have not been neglected by the Association or its members. In one of the earliest reports, Dr. Whewell calls attention to the state of crystallographical theory, and to the artificial production of crystals; and in another report, Professor Johnston notices epigene and pseudomorphous crystallisation; and for many years, at almost every meeting, new and brilliant discoveries in the action of crystals on light were made known by Brewster (z), and compared with the undulatory theory by Herschel, MacCullagh, Airy, Hamilton, Whewell, Powell, Challis, Lloyd, and Stokes.

The unequal expansion of crystals by heat, in different directions, first observed by Mitscherlich, has been carefully examined in the cases of sulphate and carbonate of lime, by Professor W. H. Miller (a), who has also considered their elasticity, originally measured in different relations to the axis by Savart. These and many other interesting relations of crystals have been attended to; but the Association has not yet succeeded in obtaining a complete digest of the facts and theories connected with the appearance of crystals in nature—in the fissures of rocks, in the smaller cavities of rocks, in the solid substance or liquid contents of other crystals. Such an enquiry, however, it did earnestly demand, and some steps have been taken by our own chemists, mineralogists, and geologists. But more abundant information on this class of subjects is still needed, even after the admirable contributions and recent discoveries of Bischof, Delesse, and Daubrée (b).

(z) "Sir David Brewster must be considered as in a degree the creator of the science which studies the mutual dependence of optical properties and crystalline forms."—[Whewell, in *Report on Mineralogy, Brit. Association*, 1832, p. 336.]

(a) Rep. Proc. 1837, pp. 43, 44.

(b) Bischof, *Chemical Geology* (published by the Cavendish Society, 1856.)

Within our Association-period both the nomenclature of chemistry and the conception of the atomic theory have received not indeed a change, but such an addition to its ordinary expression as the more general language and larger meaning of algebra have conferred on common arithmetical values. The theory of compound radicals, as these views of Liebig, Dumas, and Hofmann may be justly termed, embraces the consideration of groups of elements united in pairs by the ordinary law, these groups being for the purpose in hand treated as single elements of combination. The nomenclature which attempts in ordinary words to express these relations grows very unmanageable even in languages more easily capable of polysyllabic combinations than ours; but symbols of composition—the true language of chemistry—are no more embarrassed in the expression of these new ideas than are the mathematical symbols which deal with operations of much greater complexity on quantities more various and more variable. (c) The study of these compound radicals comes in aid of experimental research into those numerous and complex substances which appear as the result of chemical transformations in organic bodies. Thus in some instances the very substances have been recomposed by art which the vital processes are every moment producing in nature; in others the steps of the process are clearly traced; in all the changes become better understood through which so great a variety of substances and structures are yielded by one circulating fluid; and the result is almost a new branch of animal and vegetable physiology, not less important for the health of mankind than essential to the progress of scientific agriculture.

The greater our progress in the study of the economy of nature, the more she unveils herself as one vast whole—one comprehensive plan—one universal rule, in a yet unexhausted series of individual peculiarities. Such is the aspect of this moving, working, living system of force and law: such it has ever been, if we rightly interpret the history of our own portion of this rich inheritance of mind, the history of that earth from which we

Delesse, *Etudes sur le Métamorphisme*, 1858, and other works.

Daubrée, *sur la Relation des Sources Thermales des Plombières, avec les Filons Metallifères et la formation des Zeolithes*, 1858; and other works.

(c) On the Nomenclature of Organic Compounds, by Dr. Daubeny. Reports of British Association, 1851.

spring, with which so many of our thoughts are co-ordinated, and to which all but our thoughts and hopes will again return.

How should we prize this history! and exult in the thought that in our own days, within our own memories, the very foundations of the series of strata, deposited in the beginning of time, have been explored by our living friends, our Murchison and Sedgwick, while the higher and more complicated parts of the structure have been minutely examined by our Lyell, Forbes, and Prestwich (*d*). How instructive the history of that long series of inhabitants which received in primeval times the gift of life, and filled the land, sea, and air with rejoicing myriads, through innumerable revolutions of the planet, before, in the fulness of time, it pleased the Giver of all good to place man upon the earth, and bid him look up to heaven.

Wave succeeding wave, the forms of ancient life sweep across the ever-changing surface of the earth, revealing to us the height of the land, the depth of the sea, the quality of the air, the course of the rivers, the extent of the forest, the system of life and death—yes, the growth, decay, and death of individuals, the beginning and ending of races, of many successive races of plants and animals, in seas now dried, on sand-banks now raised into mountains, on continents now sunk beneath the waters.

Had that series a beginning? Was the earth ever uninhabited, after it became a globe turning on its axis and revolving round the sun? Was there ever a period since land and sea were separated—a period which we can trace—when the land was not shaded by plants, the ocean not alive with animals? The answer, as it comes to us from the latest observation, declares that in the lowest deposits of the most ancient seas in the stratified crust of the globe, the monuments of life remain. They extend to the earliest sediments of water, now in part so changed as to appear like the products of fire. What life? Only the simpler and less specially organised fabrics have as yet rewarded research among these old Laurentian rocks—only the aggregated structures of Foraminifera have been found in what, for the present, at least, must be accepted as the first deposits of the oldest sea. The most ancient of all known fossils, the *Eozoon Canadense* of Sir W.

(*d*) The investigations of Murchison and Sedgwick in the Cambrian and Silurian Strata began in 1831; the views of Sir C. Lyell on Tertiary Periods were made known in 1829.

Logan, is of this low, we may even say lowest, type of animal organisation.

Then step by step we are guided through the old Cambrian Silurian systems, rich in Trilobites and Brachiopoda, the delights of Salter and Davidson; with Agassiz and Miller, and Egerton, we read the history of the strange old fishes of Devonian rocks; Brongniart, and Göppert, and Dawson, and Binney, and Hooker unveil the mystery of the mighty forests now converted to coal; Mantell and Owen and Huxley restore for us the giant reptiles of the Lias, Oolite, and the Wealden; Edwards and Wright almost revive the beauteous corals and echinodermata; which with all the preceding tribes have come and gone before the dawn of the later periods, when fragments of mammoths and hippopotami were buried in caves and river sediments to reward the researches of Cuvier and Buckland, Prestwich and Christy, Lartet and Falconer.

And what is the latest term in this long series of successive existence? Surely the monuments of ever-advancing art—the temples whose origin is in caverns of the rocks; the cities which have taken the place of holes in the ground, or heaps of stones and timber in a lake; the ships which have outgrown the canoe, as that was modelled from the floating trunk of a tree, are sufficient proof of the late arrival of man upon the earth, after it had undergone many changes, and had become adapted to his physical, intellectual, and moral nature.

Compared with the periods which elapsed in the accomplishment of these changes, how short is the date of those yet standing monoliths, cromlechs, and circles of unhewn-stone which are the oldest of human structures raised in Western Europe, or of those more regular fabrics which attest the early importance of the monarchs and people of Egypt, Assyria, and some parts of America! Yet tried by monuments of natural events which happened within the age of man, the human family is old enough in Western Europe to have been sheltered by caverns in the rocks, while herds of reindeer roamed in Southern France (*d*), and bears and hyenas were denizens of the south of England (*e*). More

(*d*) See the Memoirs of M. Lartet on the Caves of the Dordogne, 1863-4.

(*e*) In the caves of Gower, Devon, and Somerset, flint flakes occur with several extinct animals.

than this, remains of the rudest human art ever seen are certainly found buried with and are thought to belong to races who lived contemporaneously with the mammoth and rhinoceros, and experienced the cold of a Gallic or British winter, from which the woolly covering of the wild animals was a fitting protection.

Our own annals begin with the Kelts, if indeed we are entitled to call by that historic name the really separate nations, Belgian, Iberian, and Teutonic, whom the Roman writers recognise as settlers in Britain (*f*); settlers among a really earlier family, our rudest and oldest forefathers, who may have been, as they thought themselves to be, the primitive people of the land (*g*). But beyond the Κελταί who occupied the sources of the Danube and the slopes of the Pyrenees, and were known to Rome in later days, there was present to the mind of the father of Grecian history a still more western race, the Cynetæ, who may perhaps be supposed the very earliest people of the extreme west of the continent of Europe. Were those the people, the first poor pilgrims from the East, whose footsteps we are slowly tracing in the valleys of Picardy and the south of England, if not on the borders of the lakes of Switzerland? Are their kindred still to be found among the Rhætic Alps and the Asturian cliffs, if not amid the wilds of Connemars, pressed into those mountainous recesses by the legions of Rome, the spear of the Visigoth, and the sword of the Saxon? Or must we regard them as races of an earlier type, who had ceased to chip flints before the arrival of Saxon, or Goth, or Kelt, or Cynetian? These questions of romantic interest in the study of the distribution and languages of the families of man are part of a large circle of enquiry which finds sympathy in several of our sections, especially those devoted to zoology, physiology, and ethnology. Let us not expect or desire for them a very quick, or, at present, a very definite settlement. Deep shadows have gathered over all the earlier ages of mankind, which perhaps still longer periods of time may not avail to remove. Yet let us not undervalue the progress of ethnological enquiry, nor fail to mark how, within the period to which our recollections cling, the revelations of early Egypt have been followed by a chronology of the

(*f*) Gallic or Belgian on the south-east coast; Iberian in South Wales. German at the foot of the Grampians—(Tacitus, *Vita Agricolæ*.)

(*g*) “*Britannicæ pars interior ab iis incolitur, quos natos in insula ipsa memoria proditum dicunt.*”—(Cæsar, v. 12.)

ancient kingdoms on the Tigris and Euphrates, through the same rigorous study of language. Thus has our Rawlinson added another page to the brilliant discoveries of Young and Champollion, Lepsius and Rosellini.

Nor, though obtained in a different way, must we forget the new knowledge of a people nearer home, which the philosophic mind of Keller has opened to us among his native mountains. There, on the borders of the Alpine lakes, before the great Roman general crossed the Rhone, lived a people older than the Helvetians; whose rude lives, passed in hunting and fishing, were nevertheless marked by some of the many inventions which everywhere, even in the most unfavorable situations, accompany the least civilised of mankind. Implements of stone and pottery of the rudest sort belong to the earliest of these people; while ornamented iron weapons of war, and innumerable other fabrics in that metal, appear about the later habitations, and correspond probably to the period of the true Helvetii, who quitted their home and contended with Caesar for richer settlements in Gaul. The people of whom these are the traces on almost every lake in Switzerland are recognised as well in the ancient lake-basins of Lombardy and among the Tyrolean Alps, and farther on the north side of the mountains; and probably fresh discoveries may connect them with the country of the Sarmatians and the Scythians.

Thus at length is fairly opened, for archæology and palæontology to read, a new chapter of the world's history, which begins in the pleistocene periods of geology, and reaches to the prehistoric ages of man. Did our ancestors really contend, as the poets fancied (*h*), with stones and clubs against the lion and the rhinoceros, and thus expel them from their native haunts, or have they been removed by change of climate or local physical conditions? Was the existence of the hyena and the elephant only possible in Western Europe while a climate prevailed there such as now belongs to Africa or India? and was this period of high temperature reduced in a later time for the elk, reindeer, and musk ox, which undoubtedly roamed over the hills of England and France? If we think so, what a vista of long duration stretches before us, for no such changes of climate can be supposed to have occurred except as the effect of great physical changes, requiring a lapse of many thousands of years. And though we may think such changes

(*h*) Lucretius, v. 964—1283.

of climate not proved, and probably careful weighing of evidence may justify our disbelief, still, if the valleys in Picardy have been excavated since the deposit of the gravel of St. Acheul (*i*), and the whole face of the country has been altered about the caverns of Torquay since they received remains of animals and traces of man (*j*)—how can we admit these facts and yet refuse the time required for their accomplishment? First, let us be sure of the facts, and especially of that main fact upon which all the argument involving immensity of time really turns, viz., the contemporaneous existence of man with the mammoth of the plains and the bear of the caverns. The remains of men are certainly *buried* with those of extinct quadrupeds; but did they *live* in the same days, or do we see relics of different periods gathered into one locality by natural processes of a later date, or confused by the operations of men?

Before replying finally to these questions, further researches of an exact kind are desirable, and the Association has given its aid towards them, both in respect to the old cavern of Kent's Hole, and the newly-opened fissure of Gibraltar, from which we expect great results, though the best of our laborers has ceased from his honorable toil. (*k*) When these and many other researches are completed, some future Lyell, if not our own great geologist, may add some fresh chapters to the "Antiquity of Man."

In judging of this antiquity, in counting the centuries which may have elapsed since smoothed flints fitted with handles of wood were used as chisels and axes by the earliest people of Scandinavia or Helvetia, and flakes of flint were employed to cleanse the skins of the reindeer in the caves of the Dordogne, or stronger tools broke up the ice in the valley of the Somme, we must be careful not to take what is the mark of low civilization for the indication of very remote time. In every country, among every race of men, such rude weapons and tools are used now, or were used formerly. On the banks of the Ohio, no less than on the English hills, mounds of earth, rude pottery, and stone weapons occur in abun-

(*i*) Prestwich, Transactions of the Royal Society, 1860, and Proc. of Roy. Inst., Feb., 1864.

(*j*) Pengelly, reports of the British Association, 1864.

(*k*) The late Dr. Hugh Falconer, whose knowledge of the fossil animals of caves was remarkably exact, took a great share in these examinations.

dance; and indicate similar wants, contrivances, customs, ideas, in different races of men living in different periods. Even when in the same country, as in Switzerland, or England, or Denmark, successive deposits of instruments of stone, bronze, or iron; successive burials of pines, beeches, and oaks; successively extinguished races of elephants, elks, and reindeer, give us a real scale of elapsed time, it is one of which the divisions are not yet valued in years or centuries of years.

Toward a right judgment of the length of this scale of human occupation, two other lines of evidence may be thought worthy of notice; one founded on the anatomical study of the remains of early men, the other on the laws of language. If the varieties of physical structure in man, and the deviations of language from an original type, be natural effects of time and circumstance, the length of time may be in some degree estimated by the amount of the diversities which are observed to have happened, compared with the variation which is now known to be happening. This process becomes imaginary, unless we assume all mankind to have had one local centre, and one original language. Its results must be erroneous, unless we take fully into account the superior fixity of languages which are represented in writing, and the greater tendency to diversity of every kind which must have prevailed in early times, when geographical impediments were aggravated by dissocial habits of life. It appears, however, certain that some differences of language, organisation, and habits have separated men of apparently unlike races during periods longer than those which rest on historical facts (*l*).

Ever since the days of Aristotle, the analogy existing among all parts of the animal kingdom, and in a general sense we may say among all the forms of life, has become more and more the subject of special study. Related as all living beings are to the element in which they move and breathe, to the mechanical energies of nature which they employ or resist, and to the molecular forces which penetrate and transform them, some general conformity of structure, some frequently recurring resemblance of function, must be present, and cannot be overlooked. In the several classes this analogy grows stronger, and in the subdivisions of these classes real family affinity is recognised. In the smallest divisions which have this family relation in the highest degree,

(*l*) Max Muller on the Science of Language.

there seems to be a line which circumscribes each group, within which variations occur, from food, exercise, climate, and transmitted peculiarities. Often one specific group approaches another, or several others, and a question arises whether, though now distinct, or rather distinguishable, they always have been so from their beginning, or will be always so until their disappearance.

Whether what we call species are so many original creations or derivations from a few types or one type, is discussed at length in the elegant treatise of Darwin (*m*), himself a naturalist of eminent rank. It had been often discussed before. Nor will any one think lightly of such enquiries, who remembers the essay of Linnæus, 'De Telluris orbis incremento,' or the investigations of Brown, Prichard, Forbes, Agassiz, and Hooker, regarding the local origin of different species, genera, and families of plants and animals, both on the land and in the sea. Still less will he be disposed to undervalue its importance, when he reflects on the many successive races of living forms more or less resembling our existing quadrupeds, reptiles, fishes, and mollusca, which appear to have occupied definite and different parts of the depths of ancient time; as now the tiger and the jaguar, the cayman and the gavial, live on different parts of the terrestrial surface. Is the living elephant of Ceylon the lineal descendant of that mammoth which roamed over Siberia and Europe, and North America, or of one of those sub-Himalayan tribes which Dr. Falconer has made known; or was it a species dwelling only in circumpolar regions? Can our domestic cattle, horses and dogs, our beasts of chase and our beasts of prey, be traced back to their source in older types, contemporaries of the urus, megaceros, and hyena on the plains of Europe? If so, what range of variation in structure does it indicate? If not so, by what characters are the living races separated from those of earlier date?

Specific questions of this kind must be answered, before the general proposition, that the forms of life are indefinitely variable with time and circumstance, can be even examined by the light of adequate evidence. That such evidence will be gathered and rightly interpreted, I for one neither doubt nor fear; nor will any be too hasty in adopting extreme opinions or too fearful of the final result, who remember how often that which is true has been found very different from that which was plausible, and how

often out of the nettles of danger we have plucked the flowers of safety. At the present moment the three propositions which were ever present to the mind of Edward Forbes may be successfully maintained, as agreeing with many observed phenomena; and around them, as a basis of classification, may be gathered most of the facts and most of the speculations which relate to the history of life (*n*). First, it may be admitted that plants and animals form many natural groups, the members of which have several common characters, and are parted from other groups by a real boundary line, or rather unoccupied space. Next, that each of these groups has a limited distribution space, often restrained by high mountains or deep seas, or parallels of temperature, within which it has been brought into being. Thirdly, that each group has been submitted to, or is now undergoing, the pressure of a general law, by which its duration is limited in geological time; the same group never re-appearing after being removed from the series.

How important, in the view of this and many other questions, is that never-tiring spirit of geographical and maritime discovery, to which through four hundred years Europe has sent her noblest sons and her most famous expeditions; sent them, alas! too often to an early grave. Alas! for Franklin, who carried the magnetic flag into the Icy Sea from which he had already brought trophies to Science! Alas! for Speke, who came home with honor from the head waters of the Nile! Forgotten they can never be, whenever on occasions like this, we mourn the absence of our bravest and our best; praise, neverending praise be theirs, while men retain the generous impulse which prompts them to enterprises worthy of their country and beneficial to mankind!

If it may be asked, what share in the discoveries and inventions of the last thirty-three years is claimed for the British Association, let us answer fearlessly, We had a part in all. In some of them we took the foremost place by the frequency of our discussions, the urgency of our recommendations, the employment of our influence, and the grant of our funds. For others we gave all our strength, to support the Royal Society and other institutions in their efforts to accomplish purposes which we approve. In all instances our elastic system responds quickly to pressure, and

(*n*) See the remarkable essay of E. Forbes on the distribution of the existing Fauna and Flora of the British Isles, in *Memoirs of Geol. Survey of Britain*, vol. i, p. 336.

returns the friendly impulse. If we look back on the work of previous years, it is easy to mark the special action of the Association in fields which hardly could be entered by any other adventurers.

Many of the most valuable labors of which we are now reaping the fruits were undertaken in consequence of the reports on special branches of science which appear in the early volumes of our Transactions—reports in which particular data were requested for confirming or correcting known generalisations, or for establishing new ones. Thus, a passage in Professor Airy's report on Physical Astronomy (*o*) first turned the attention of Adams to the mathematical vision of Neptune; Lubbeck's Report on Tides (*p*) came before the experimental researches and reductions, which since 1834 have so often engaged the attention of Whewell and Airy and Haughton, with results so valuable and so suggestive of further undertakings. Among these results may be placed additional knowledge of the probable depth of the channels of the sea. For, before the desire of telegraphic communication with America had caused the bed of the North Atlantic to be explored by soundings to a depth seldom exceeding three miles, there was reason to conclude from the investigations of Whewell on Cotidal Lines (*q*) that a depth of nine miles was attained in the South Atlantic, and from the separate computations of Airy and Haughton that a somewhat greater depth occurred in a part of the course of the tide-wave which washes the coast of Ireland (*r*). The greater portion of the sea-bed is within the reach of soundings directed by the superior skill and greater perseverance of modern scientific navigators; a depth of six miles is said to have been reached in one small tract of the North Atlantic; depths of nine or ten miles in the deepest channels of the sea are probable from considering the general proportion which is likely to obtain between sea-depths and mountain-tops. Thus the data are gradually being collected for a complete survey of the bed of the sea, includ-

(*o*) Reports of the British Association for 1832, p. 154. Laplace had indeed observed that "the planet Uranus and his satellites, lately discovered, give reason to suspect the existence of some planets not yet observed;" thereby encouraging the search for new discoveries, in our own system.—(Exp. du Syst. du Monde, 1799, 4to, p. 350.)

(*p*) Reports of the British Association, 1832.

(*q*) Trans. of Roy. Soc., 1833.

(*r*) Trans. of Roy. Irish Acad., 1855.

ing, among other things, information, at least, concerning the distribution of animal and vegetable life beneath the waters.

Waves — their origin, the mechanism of their motion, their velocity, their elevation, the resistance they offer to vessels of given form : these subjects have been firmly kept in view by the Association, since first Professor Challis (*s*) reported on the mathematical problems they suggest, and Sir J. Robinson and Mr. Scott Russell undertook to study them experimentally (*t*). Out of this enquiry has come a better knowledge of the forms which ought to be given to the 'lines' of ships, followed by swifter passages across the sea, both by sailing vessels and steamers, of larger size and greater lengths than ever tried before. (*u*)

One of the earliest subjects to acquire importance in our thoughts, was the unexplored region of meteorology laid open in Professor J. Forbes' Reports (*x*). Several of the points to which he called attention have been successfully attained. The admirable instruments of Whewell, Osler, and Robinson have replaced the older and ruder anemometers, and are everywhere in full operation, to record the momentary variations of pressure, or sum the varying velocities of the wind. No small thanks were due to Mr. Marshall and Mr. Miller (*y*) for their enterprise and perseverance in placing rain gauges and thermometers amidst the peaks of Cumberland and Westmoreland. These experiments are now renewed in both countries, and in North Wales; and I hope to hear of similar efforts among the mountains of the west of Ireland and the west of Scotland. Our meteorological instruments of every kind have been improved; our system of photographic registration has spread from Kew into other observatories; and our corresponding member, Professor Dove, has collected into systematic maps and tables the lines and figures, which represent annual and monthly climate over every land and sea.

In the same manner, by no sudden impulse or accidental circumstance, rose to its high importance that great system of magnetic observations, on which for more than a quarter of a century the Brit-

(*s*) Reports of the British Association, 1833, 1836.

(*t*) Ibid., 1837 and following years.

(*u*) Ibid., 1840-1843.

(*x*) Reports of the British Association, 1832-1840.

(*y*) Mr. Marshall's observations were made in Patterdale, Mr. Miller's about Wastdale Head. (British Association Reports for 1846, and Royal Society's Transactions, 1850.)

ish Association and the Royal Society, acting in concert, have been intent. First, we had reports on the mathematical theory and experimental researches of magnetism by Christie, 1833, Whewell, 1835, and Sabine, 1835;—afterwards a magnetic survey of the British Islands (*z*); then, the establishment of a complete observatory at Dublin, with newly arranged instruments, by Dr. Lloyd, in 1838. On all this gathered experience we founded a memorial to her Majesty's Government, made a grant of £400 from our funds for preliminary expenses, and presented to the meeting of this Association in Birmingham, in 1839, a report of progress, signed by Herschel and Lloyd. From that time how great the labor, how inestimable the fruits! Ross sails to the magnetic pole of the south; America and Russia co-operate with our observers at Kew, Toronto, and St. Helena; and General Sabine, by combining all this united labor, has the happiness of seeing results established of which no man dreamed—laws of harmonious variation affecting the magnetic elements of the globe, in definite relation to the earth's movement, the position of the sun and moon, the distribution of temperature, and the situation in latitude and longitude (*aa*).

Our efforts have not been fruitless, whether with Mr. Mallet we make experiments on artificial earth-shocks at Dalkey, or survey the devastations round Vesuvius, or tabulate the records of earthquakes since the beginning of history (*bb*); or establish the Kew Observatory as a scientific workshop where new instruments of research are made and proved and set to work (*cc*); or dredge the sea with Forbes, and Brady, and Jeffreys (*dd*); or catalogue the

(*z*) The survey was begun in Ireland in 1835, by Lloyd, Sabine, and Ross; and completed in England, Wales, and Scotland, in 1837, by the same magneticians, assisted by Fox and Phillips. It was repeated in 1857 and following years by Sabine, Lloyd, Welsh, Haughton, Galbraith, and Stoney.

(*aa*) Trans. of the Royal Society for many years; Reports of the British Association, 1840 and following years; Rede Lecture, 1862.

(*bb*) British Association Reports; Experiments at Dalkey, 1853; Report on Earthquakes, 1840–1858. See also the excellent communications of M. Perrey to the Memoirs of the Academy of Dijon.

(*cc*) The Kew Observatory became a part of the system of the Association in 1842.

(*dd*) See reports of the Dredging Committees from 1842 to 1864; Nat. Hist. Trans. of Northumberland and Durham; Jeffreys's British Conchology.

stars with Baily (*ee*) ; or investigate electricity with Harris, Ronalds, Thomson, and Jenkin (*ff*) ; or try the action of long-continued heat with Harcourt (*gg*) ; in these and a hundred other directions, our attempts to gain knowledge have brought back new facts and new laws of phenomena, or better instruments for attaining, or better methods for interpreting them. Even when we enter the domain of practical art, and apply scientific methods to test a great process of manufacture, we do not fail of success, because we are able to join in united exertion the laborious cultivators of science and the scientific employers of labor.

Am I asked to give an example? Let it be iron, the one substance by the possession of which, by the true knowledge and right use of which, more than by any other thing, our national greatness is supported. What are the ores of iron—what the peculiarities and improvements of the smelting processes—what the quality of the iron—its chemical composition—its strength in columns and girders as cast iron ; in rails and boiler plate, in tubes and chains, as wrought iron—what are the best forms in which to employ it, the best methods of preserving it from decay ? —these and many other questions are answered by many special reports in our volumes, bearing the names of Barlow, Mallet, Porter, Fairbairn, Bunsen, Playfair, Percy, Budd, Hodgkinson, Thomson ; and very numerous other communications from Lucas, Fairbairn, Cooper, Nicholson, Price, Crane, Hartley, Davy, Mushet, Hawkes, Penny, Scoresby, Dawes, Calvert, Clark, Cox, Hodgkinson, May, Schafhaeutl, Johnston, Clay, and Boutigny. Beyond a question, a reader of such of these valuable documents as relate to the strength of iron, in its various forms, would be far better informed of the right course to be followed in experiments on armor-plated ships and forts to resist assault, and in the construction of ordnance to attack them, than is likely to be from merely witnessing a thousand trials of the cannon against the target. Any one who remembers what the iron furnace was forty years ago, and knows its present power of work ; or who contrasts the rolling mills and hammers of other days, with the beautiful machines which now, with the gentlest motion but irresistible

(*ee*) British Association Catalogue of Stars, 1845.

(*ff*) The latest result of these researches is an instrumental standard of electrical resistance. (Reports of the British Association, 1863–1864.)

(*gg*) Reports of the British Association, 1846–1860.

force, compel the strong metal to take up the most delicately moulded form, will acknowledge, that within the period since the British Association began to set itself to the task of reconciling the separated powers of theory and experience, there has been a total change in the aspect of each, to the great advantage of both.

Our undertakings have not been fruitless. We attempted what we had well considered, and had the power to accomplish; and we had the more than willing help of competent persons of our own body, the friendly aid of other institutions, and the sanction of the Government, convinced of the sincerity of our purpose and the wisdom of our recommendations.

The same work is ever before us; the same prudence is always necessary; the same aid is always ready. Great, indeed, should be our happiness in reflecting on the many occasions, when the Royal Society in particular, and other institutions older than our own, have readily placed themselves by our side, to share our responsibility and diminish our difficulties. But for this, our wishes might not always have prevailed; and the horizon of science would not have been so clear as now it is. Of late years, indeed, societies formed on our model have taken up special parts of our work, and thus, to some extent, have relieved us of the pressure of communications relating to the practice of particular professions and the progress of some public questions. Not that scientific agriculture, social statistics, or physiology, are neglected in our meetings, but that these and other practical subjects are found to have more than one aspect, and to require more than one mode of treatment. With us, facts well ascertained, conclusions rightly drawn, will ever be welcome, from whatever quarter of the horizon of science they make their appearance. Whatever societies cultivate these objects, they are our allies, and we will help them, if we may. With pleasure we receive proofs of the good work done in limited districts by the many admirable Field Clubs formed by our countrymen; whether, like those of Tyne-side and the Cotswolds, and in this immediate vicinity those of Warwickshire, Worcestershire, and Dudley, they explore the minutest recesses of our hills and glens; or, like the rangers of the Alps, bring us new facts regarding glaciers, ancient climates, and altered levels of land and sea.

By these agreeable gatherings natural history is most favorably commended; and in the activity and enlarged views of the officers who conduct them, the British Association recognizes the

qualities, by which the vitality of scientific research is maintained, and its benefits diffused among the provincial institutions of the empire.

Such, gentlemen, are some of the thoughts which fill the minds of those, who, like our Brewster, and Harcourt, and Forbes, and Murchison, and Daubeny, stood anxious but hopeful, by the cradle of this British Association; and who now meet to judge of its strength, and measure its progress. When, more than thirty years ago, this Parliament of Science came into being, its first child-language was employed to ask questions of nature; now, in riper years, it founds on the answers received further and more definite enquiries directed to the same prolific source of useful knowledge. Of researches in science completed, in progress, or in beginning, each of our annual volumes contains some three hundred or more passing notices, or full and permanent records. This digest and monument of our labors, is, indeed, in some respects, incomplete, since it does not always contain the narrative or the result of undertakings which we started, or fostered, or sustained; and I own to having experienced on this account once or twice a feeling of regret. But the regret was soon lost in the gratification of knowing that other and equally beneficial channels of publication had been found; and that by these examples it was proved how truly the Association kept to the real purpose of its foundation, 'the Advancement of Science,' and how heartily it rejoiced in this advancement without looking too closely to its own share in the triumph. Here, indeed, is the stronghold of the British Association. Wherever and by whatever means sound learning and useful knowledge are advanced, these to us are friends. Whoever is privileged to step beyond his fellows on the road of scientific discovery, will receive our applause, and, if need be, our help. Welcoming and joining in the labor of all, we shall keep our place among those who clear the roads and remove the obstacles from the paths of science; and whatever be our own success in the rich fields which lie before us, however little we may now know, we shall prove, that in this our day we know at least the value of knowledge, and join hearts and hands in the endeavor to promote it.

Sir Roderick Murchison proposed a vote of thanks to the President, for his address, in highly eulogistic terms.

ADDRESS TO THE GEOLOGICAL SECTION

BY SIR RODERICK MURCHISON, K. C. B.

It is now nineteen years since I presided over the British Association; and fifteen years have elapsed since I occupied the geological chair; for, although I have not in the meantime ceased to use my hammer, and though I still cling as keenly as ever to this my own special science, I have, in what I consider its enlarged sense, been led to endeavor to advance, in late years, by every means in my power, the sister science of Geography. I have thus had the happiness to see that, whilst the comparatively new Section of Geography and Ethnology has become very popular, and is always crowded, at all our recent meetings Section C treating, as it does, of the true foundation of geography, has been quite as well attended as ever; and I trust that on this occasion our room will be as well filled as it has ever been in previous years, when this section was presided over by a Buckland, a Sedgwick, a Delabèche, a Lyell, and a Phillips.

Great indeed have been the advances made in geological science in the sixteen years which have elapsed since our last meeting in Birmingham. For although at that time the bases of the classification of the older rocks were then firmly established, still our knowledge of the correlations and contents of the several formations ascending from the oldest stratified rocks in which we could distinguish the remains of life has since been materially extended.

The lowest sedimentary rock, which, with most geologists, I considered to be azoic, or void of life, simply because at that time nothing organic had been discovered in them, have, through the labors and discoveries of Sir William Logan and his associates in Canada been found to contain a zoophyte, which they termed *Eozoon Canadense*. But the rocks containing this fossil were named Laurentian by Logan long before that fossil was detected in them, and simply because they clearly underlie all the rocks of Cambrian and Silurian age. On the same principle of infraposition, it was my good fortune to be able, in 1855, to point out the existence of these same ancient rocks on a large scale in the north-west Highlands of Scotland; and though I at first termed them Fundamental Gneiss, as soon as I heard of Logan's discovery in North America I adopted his name of Laurentian.

In our islands, however, nothing organic has been discovered as

yet in these our British fundamental rocks, though they are truly of Laurentian age. For although it was supposed for a moment that the rocks of the Connemara district in the west of Ireland were also of that high antiquity, because it was said that they contained an *Eozoon*, I assert, from my own examination*, as well as from information obtained during a recent visit by Professor Harkness, that the quartzose, gneissose, and calcareo-serpentinous strata of the Bins of Connemara, in which the supposed *Eozoon* was said to exist, are simply metamorphosed Lower Silurian strata. Professor Harkness will explain this point to you, and will further, I believe, endeavor to convince you that there is no organic structure whatever in the serpentinous rock of Connemara. But, whatever may be the decision of microscopists, I must, as a geologist, declare that, inasmuch as zoophytes of a low order (Foraminifera) unquestionably occur in Laurentian rocks, so it was by no means improbable that the same group of low animals, having, as far as we can detect, no antagonistic contemporaries, and having been, therefore, free from any "struggle for existence," might have continued to be the inhabitants of sea shores and cliffs during the long succeeding epoch.

The mere presence of an *Eozoon* is therefore no proof whatever that the rock in which it occurred is of the "Fundamental" or "Laurentian" age, that point being only capable of settlement by a clear infraposition of the rocks to well-known and clearly defined Lower Palæozoic deposits, in the lowest of which, or the Cambrian of the Geological Survey, another form of low zoophyte, and a few worm-tracks have, as yet, alone been detected.

In a word, this discovery of a foraminifer in the very lowest known deposit, instead of interfering with, sustains the truth of that doctrine which all my experience as a geologist has confirmed, that the lowest animals alone occur in the earliest zone of life, and that this beginning was followed through long periods by creations of higher and higher animals successively. Thus through the whole of the vastly long Lower Silurian period, so rich in all the lower classes of marine animals, whether mollusks, crustaceans, or zoophytes, no one has yet detected a vertebrated creature. Fishes first begin to appear in the latest Silurian deposit, from which time to the present day they have never ceased to prevail; and new forms of Vertebrata, adapted to each succeeding

* See 'Siluria,' p. 190.

period, have followed each other. Every geologist knows how, in the overlying Secondary and Tertiary formations, higher and higher grades of animals successively appear; and how the relics of man or his works have been detected in the youngest only of the Tertiary deposits, though certainly at a period long anterior to all history. We now well know that human beings coexisted with quadrupeds which are extinct; and we also know that the physical configuration of the surface has undergone considerable changes since such primeval men lived. This subject, opened out in France by M. Boucher de Perthes, followed by some of his distinguished countrymen, has in our country received much illustration at the hands of Prestwich, Lyell, Falconer, Lubbock, Evans, and others, and is now a well-established doctrine.

But the great feature at the other end of the geological series, to which I revert, is the uncontradicted fact, which has been passed over by many writers, or misrepresented by others, that there were enormously long periods, following that of the primeval zoophytic deposits, during which the seas, though abounding in all other orders of animals, were not tenanted by fishes.

As this is a fact which the researches, during thirty years, of many geologists, amidst the Lower Silurian rocks in all parts of the world, have been unable to invalidate, so it teaches us, in our appeal to the works of nature, that there was a beginning as well as a progress of creation, and that those writers, however eminent, who have announced that fishes, mollusks, and other invertebrata appeared together, have asserted that which is positively at variance with the results of the researches of this century. As I have in various works pointed out this great fundamental principle in the origin of successive faunæ, and as at my age I may probably never again occupy a geological chair, I hope therefore to be excused for looking back with some pride, now that I am on the eastern borders of my Silurian region, to the period when, thirty years ago, I dwelt on the then novel fact, never since contravened, that "the fishes of the Upper Silurian rocks appeared before naturalists as the most ancient beings of their class."* Enormous regions in Europe and America over which these

* See 'Silurian System,' p. 605. Though the work was not published until 1838-39, the Silurian system and its characters were established by me in 1835 (see 'London, Edinburgh, and Dublin Philosophical Magazine,' 3rd series, vol. vii, p. 46, 1835).

Silurian rocks extend have, I repeat, been long harried, with an intense desire on the part of many searchers to find something which would gainsay the datum-line that marks the beginning of vertebrated life; and, as all these efforts have failed, I have some right to insist upon the value of such a vast amount of what those who seek to oppose this view still persist in calling negative evidence. The facts however remain, and on them I rest my belief.

In this short introductory address I cannot attempt to present to you a sketch of the general recent progress of geological science in other parts of Europe or in America. This must be sought in the well-digested recent address of the actual President of the Geological Society, Mr. W. J. Hamilton. I must, for the most part, confine my observations to certain British questions, the more so as I know that our distinguished associates of other countries, who honor us by their presence on this occasion, come to us mainly for the purpose of ascertaining the progress we have made in our isles, and also with the view of visiting those of our typical localities of which they have read.

Among those visitors from abroad, I must first allude to my eminent friend, M. Henri von Dechen, the director of the mines of Prussia. In speaking of him, I turn back to the year 1827 (four years before the foundation of the British Association), when he and his associate Oeynhausen explored our islands, and when it was the good fortune of Professor Sedgwick and myself to examine parts of the Highlands of Scotland in company with those able young German geologists, who have since risen to such high distinction. Of him who is now present, I will only say that the great geological map of the Rhine Provinces, of which he has been the director, is a work of special value to English geologists. In this map are delineated with precision the whole series of the Palæozoic rocks on both banks of the Rhine, from those Devonian limestones of the Eifel which were correlated with our own by Sedgwick and myself, to the Coal-measures and the several Tertiary and superficial deposits, as well as all the rocks of igneous origin; in it are also elaborated in the most skilful manner all the numerous intermediate strata, of Devonian and Mountain-limestone age, which are wanting in the immediate vicinity of Birmingham, but which have to a great extent their equivalent representatives in other parts of our islands. Whilst for the subordinate strata thus delineated M. von Dechen and all Prussian geologists naturally employ local names, I am glad to find that the

general groups of the Silurian, Devonian, and Carboniferous are thoroughly recognized by him and his associates according to the divisions established in Britain, and of which our father William Smith set the first example, by his admirable identification of the strata of the Secondary rocks by their fossils and order of superposition.

My veteran German friend is accompanied by another of his countrymen, Professor Ferdinand of Roemer, of Breslau, whose works have justly earned for him a very high position, particularly in palæontology; and whilst one of these is upon Texas, in the United States of America, let me say how fortunate we are in having among us Principal Dawson, of Montreal, in Canada, whose merits are so well known to every reader of the volumes of Lyell and the Quarterly Journal of the Geological Society of London. There may indeed be present several distinguished visitors from distant countries, with whose arrival or intention of coming hither I am unacquainted whilst I write; but in relation to our nearest neighbors, the French, it gave me great pleasure when I learned that our younger Foreign Associates were to be led by M. A. Gaudry, once President of the Geological Society of France. Now, all these visitors will, I doubt not, rejoice in having the opportunity of studying the varied relations of the sedimentary and eruptive rocks in the vicinity of this flourishing hive of human industry. These and other foreign visitors, as well as our associates from different parts of the United Kingdom, will necessarily take a deep interest in comparing the varied rocks and their fossils, which are grouped around our place of meeting, with the sedimentary and eruptive rocks of their own several districts.

Among the recent important additions to our knowledge of the geographical distribution and characters of the Silurian rocks, I cannot but advert to the successful labors of Professor Harkness. He had already shown in the clearest manner, by the evidence of fossils and order of succession, that the lowest of the strata in the Cambrian district of the Lakes, the slates of Skiddaw, are truly of Lower Silurian age, and not older than the Llandeilo group. Recently, in pursuing his labors, he has detected fossils in the "green slates" or volcanic ashes and porphyries which lie intermediate between the Skiddaw strata and the higher Silurian; and he has further found others in the Coniston Flags, which he views as equivalents of the upper part of the Caradoc formation. Further, Professor Harkness has shown, for the first time, that

the slaty rocks of Westmoreland, which separate the Carboniferous limestone from the Permian of the Vale of the Eden, contain Lower Silurian fossils similar to those of Cumberland. I hope also to learn from him at this meeting what has been the effect of certain great faults ranging from north to south, which have impressed a grand and picturesque outline on that region, and upon the lines of which are situated the most striking of the lakes of the north-west of England.

Although no Lower Silurian rocks, properly so called, occur near Birmingham, one adjacent tract, the Lickey, offers a characteristic example of the lowest of the Upper Silurian rocks, in the form of quartz-rock; whilst the limestones and shales of Dudley, and their beautiful fossils, surmounted by those of Sedgely, are very rich and characteristic of part of the overlying Ludlow and Aymestry series. I am glad to find that the members of the Dudley and Midland Geological Society will not only communicate to us papers on the different organic remains of these deposits, but will also point out the relations of these rocks to others in the west, where the whole Silurian system is more fully developed. We shall also, I hope, have fresh illustrations of the effect of the eruptions of the basaltic and igneous rocks of the Rowley Hills, and other similar bosses, upon the Palæozoic strata which they penetrate.

Above all, the mining public and proprietors in the Midland Counties will, I am certain, be well instructed by the evening lecture to be given by my friend and associate Professor Jukes, who so distinguished himself, by his descriptions and maps of this his native district, as justly to entitle him to be placed at the head of the geological Survey of Ireland, which for many years he has conducted with great ability. He can, no doubt, indicate to you the extent to which profitable works in coal are likely to be carried out, by sinkings through that Lower Red Sandstone of the central counties which is now termed Permian, a name proposed by myself in 1841, as taken from a large province in Russia, because I there found sandstones and limestones of the same age, extending over a region much larger than France. The sinkings, which were successfully made through this deposit at Christchurch by the late Earl of Dartmouth, only four miles to the west of Birmingham, induced me, twenty-seven years ago, to write thus:—"It is, indeed, impossible to mention this enterprise, without congratulating geologists on the effects which their writings are now produ-

cing on the minds of practical men, since it was entirely owing to inferences deduced from geological phenomena that this work was commenced, whilst its success was derided by many of the miners of the adjacent coal-field."

If that enterprise has not been extensively followed, we must recollect, that, to sink shafts to depths of many hundred feet can in central England scarcely be profitable, so long as coal is found so much nearer the surface, as in the South Staffordshire field; yet, as that field is tending towards exhaustion, it is cheering to know that extensive beds of coal will be worked in future ages under the red lands of the Midland counties and the Magnesian Limestone of Nottinghamshire, under which the great Derbyshire coal-field passes; and hence all present estimates of the duration of our coal-supply must be more or less fallacious, if such high probabilities be left out of the estimate. At the same time it must be admitted that we are consuming this staple of our national greatness at so rapidly increasing a ratio, that the value of the warning voice of Sir William Armstrong at the Newcastle Meeting of the Association, when he told us that, with a continued yearly increase of two and three-quarter millions of tons, our coal-supply would be exhausted in little more than two centuries, is well sustained. Now when this announcement was made, the average total annual produce, as ascertained by the Mining Record Office of the Museum of practical Geology, amounted to eighty-six millions of tons; but by the estimate of last year, as prepared by Mr. Robert Hunt, and to which I have recently affixed my name, the produce has risen to the astounding figure of ninety-three millions of tons. Such is our own natural industry and enterprise that not more than $9\frac{1}{2}$ per cent. of this enormous quantity is exported for the use of foreign countries, among which France receives but 1,400,000 tons per annum.

Passing from the consideration of these deep-seated subjects to the superficial deposits of the country around Birmingham, I would advise any of my associates who have not witnessed the phenomena to repair to the parishes of Trescott and Trysull, and the adjacent hills to the west of Wolverhampton, there to see a quantity of blocks of granitic and other hard northern rocks, all foreign to the district, which were evidently carried by icebergs floating in the sea which covered this flat and undulating region in the heart of England during that glacial period when Scotland was what Greenland is now—an ice-clad region, whence icebergs, transporting

blocks of stone, were floated southwards from great Scottish glaciers which protruded into the sea.

Coming hither in ignorance of what the several associations of local geologists (which rival each other in their researches) have accomplished, I shall be happy to learn that some of them have detected, in this portion of the kingdom, any of those proofs of the existence of man at an early period, when large animals, now extinct, prevailed in our islands, in ages so remote that, since then, the physical configuration of the country has undergone great changes. This inference is, as I have said, founded upon irrefragable evidence collected in different parts of Europe, as well as in our own country. When, however, we come to consider the *modus operandi* by which these great physical changes have been brought about, geologists have different opinions. As one who holds to the belief that in former periods the crust of the earth was from time to time affected by an agency much more powerful than anything which has been experienced in the historic era, I do not believe that the wear and tear due to atmospheric subaërial erosive agency could, even after operating for countless ages, have originated and deepened any of the valleys and gorges which occur in countries as flat as the tract in which we are now assembled.

But whilst I adhere to my long-cherished opinion as to the great intensity of power employed in the production of dislocations of the crust of the earth, and though I cannot subscribe to the doctrine that the ordinary action of deep seas remote from coasts can adequately explain the denudation of the old surface, even by invoking any amount of time, I recognize with pleasure the ability displayed by my able associates, Ramsay, Jukes, and Geikie, in sustaining views which are to a great extent opposed to my own in this department of Theoretical Geology.

Admiring the Huttonian theory, as derived from reasoning upon my native mountainous country, Scotland, and fully admitting that on adequate inclines ice and water must, during long periods, have produced great denudation of the rocks, I maintain that such reasoning is quite inadequate to explain the manifest proofs of convulsive agency which abound all over the crust of the earth, and even are to be seen in many of the mines in the very tract in which we are assembled. Thus, to bring such things to the mind's eye of persons who are acquainted with this neighborhood, I do not apprehend that those who have examined the tract of Coalbrook Dale will contend that the deep gorge in which the Severn there flows

has been eaten out by the agency of that river, the more so when the deep fissure is at once accounted for when we see the abrupt severance that has taken place between the rocks which occupy its opposite sides. In that part of Shropshire, the Severn has not worn away the rocks during the historic era, nor has it produced a deeper channel; whilst in its lower parts it has only deposited silt and mud, and increased the extent of land on its banks.

Then, if we turn to the district in which we were last assembled, the valley at Bath is known to be the seat of one of those disturbances to which my eminent friend Sir Charles Lyell candidly applied the term "convulsion"; the hot waters of that city having ever since flowed out of a deep-seated fissure, clearly marked by the strata on the one side of the valley having been upheaved to a height very different from that which they once occupied in connexion with those of the other side. When, indeed, we look to the lazy-flowing, mud-collecting Avon, which at Bath passes along that line of valley, how clearly do we see that it never scooped out its channel; still more, when we follow it to Bristol, and observe it passing through the deep gorge of Mountain-limestone at Clifton, every one must then be convinced that it never could have produced such an excavation. In fact, we know that, from the earliest periods of history, it has only accumulated mud, and has never worn away any portion of the hard rock.

From such data I conclude that we cannot apply to flat regions, in which water has no abrading power, the same influence which it exerts in mountainous countries; whilst we are also compelled to admit that the convulsive dislocations of former periods produced many of those gorges in which our present streams flow. To pass, indeed, from the environs of Bath and Bristol, and even from the less distant Coalbrook Dale, you have only to contemplate the tract which lies between Birmingham and Dudley, and endeavor to satisfy the mind as to the process by which it has been planed down before the surface was covered by the Northern Drift; for the great dislocations which this tract has undergone, as proved by many subterraneous workings, must have left a highly irregular surface, which was so levelled by some very active causes as to obliterate the superficial irregularities corresponding with the interior disturbances. In short, what was this great power of denudation which took place in a tract where there are no mountains whence powerful streams descended, and in which there are no traces of fluviatile action? Must we not, in candor, admit

that such denudation is as difficult to account for as it is to explain by what possible gradual agency the vast interior of the valley of elevation of the Weald of Sussex and Kent, and that of the smaller valley of Woolhope in Herefordshire, have been so absolutely and entirely denuded of every fragment of the enormous masses of débris which must have encumbered these cavities, as derived from the rocks which once covered them? Placing no stint whatever on the time which geologists must invoke to satisfy their minds as to the countless ages which elapsed during the accumulations of sediment, I reject as an assumption which is at variance with the numberless proofs of intense disturbance, that the mechanical disruptions of former periods, and the overthrow of entire formations, as seen in the Alps and many mountain chains, can be accounted for by any length of action of existing causes.

A GEOGRAPHICAL, SKETCH OF CANADA.*

The great basin of the St. Lawrence, in which the province of Canada is situated, has an area of about 530,000 square miles. Of this, including the gulf of St. Lawrence, the river, and the great lakes, to Lake Superior inclusive, about 130,000 square miles are covered with water, leaving for the dry land of this basin an area of 400,000 square miles, of which about 70,000 belong to the United States. The remaining 330,000 square miles constitute the province of Canada. With the exception of about 50,000 square miles belonging to Lower Canada, and extending from the line of New York to Gaspé, the whole of this territory lies on the north side of the St. Lawrence and the great lakes.

On either side of the valley of the lower St. Lawrence is a range of mountainous country. The two ranges keep close to the shores for a considerable distance up the river; but about 100 miles below Quebec, where the river is fifteen miles wide, the southern range begins to leave the margin, and opposite to Quebec is thirty miles distant. From this point it runs in a more southern direction than the river-valley, and opposite to Montreal is met

* The following pages are extracted from a small pamphlet on Canada, prepared by Dr. T. Sterry Hunt, at the request of the Minister of Agriculture, for distribution at the Exhibition held at Dublin in 1865. As containing a brief and popular description of the topography and the soils of the Province they may not be without interest to our readers.

with about fifty miles to the south-east, where it enters Vermont, and is there known as the Green Mountain range, which forms the eastern limit of the valley of Lake Champlain. In Canada, this range, stretching from the parallel of 45° north latitude to the Gulf, is known as the Notre-Dame Mountains, but to its north-eastern portion, the name of the Shickshock Mountains is often given.

The flank of the northern hills, known as the Laurentides, forms the north shore of the river and gulf, until within twenty miles of Quebec. It then recedes, and at the latter city is already about twenty miles distant from the St. Lawrence. At Montreal the base of the hills is thirty miles in the rear, and to the westward of this it stretches along the north side of the Ottawa River for about 100 miles, and then runs southward across both the Ottawa and the St. Lawrence, crossing the latter river a little below Kingston, at the Thousand Islands, and entering New-York. Here the Laurentides spread out into an area of about 10,000 square miles of high lands, known as the Adirondack region, and lying between the Lakes Champlain and Ontario. The narrow belt of hill-country which connects the Adirondacks with the Laurentides north of the Ottawa, divides the valley of the St. Lawrence proper from that of the great lakes, which is still bounded to the north by a continuation of the Laurentides. The base of these from near Kingston runs in a western direction, at some distance in the rear of Lake Ontario, until it reaches the south-west extremity of Georgian Bay on Lake Huron; after which it skirts this lake and Lake Superior, and runs north-westward into the Hudson Bay Territory. This great northern hill-region consists of the oldest known rock-formation of the globe, to which the name of the Laurentian system has been given, and occupies, with some small exceptions, the whole of the province northward of the limits just assigned. We shall designate it as the LAURENTIAN REGION. Over a small portion of this area, along Lakes Huron and Superior, and farther eastward on Lake Temiscaming is another series of rocks, to which the name of the Huronian system is given. But as the country occupied by these rocks is geographically similar to the Laurentian, it is for convenience here included with it.

To the south of this region the whole of Canada west of Montreal, with the exception of the narrow belt of Laurentian country described as running southward across the Ottawa and St. Lawrence Rivers, is very level. The same is true to the eastward of Montreal until we reach the Notre-Dame range of hills, already

described as passing southward into Vermont, and in its north-eastern extension as bounding the lower St. Lawrence valley to the south. This valley may be regarded geographically as an extension of the great plains of western Canada and central New York, with which it is connected through the valley of Lake Champlain. This level country to the south of the Laurentides in the two parts of the province is occupied by similar rock formations, and constitutes the CHAMPAIGN REGION of Canada, the surface of which is scarcely broken, except by a few isolated hills in the vicinity of Montreal, and by occasional escarpments, ravines, and gravel ridges farther westward.

The next area to be distinguished consists of the Notre-Dame range on the south side of the St. Lawrence which forms the belt whose course has just been described, with an average breadth of from thirty to forty miles. To the south and east of this, is a district of undulating land, which extends to the boundaries of the province in that direction. These two districts may for convenience in farther description be classed together, and they embrace the region which is generally known as the EASTERN TOWNSHIPS. By this term they are distinguished from the SEIGNIORIES, which bound them to the north and west. To the north-east, however, along the Chaudiere River, some few seigniories are found within the geographical limits of this third region.

The whole of the province is well watered with numerous large and small rivers, and in the mountainous districts there are great numbers of small lakes, more than 1,000 of which are represented on the maps.

We have in the preceding description divided the country into three distinct regions, and have next to consider the geological structure of these as related to the soil and to its agricultural capabilities.

THE LAURENTIAN REGION.—The great tract of country occupied by the Laurentian rocks has for its southern boundary the limits already assigned, and stretches northward to the boundary of the province, which is the height of land dividing the waters of the St. Lawrence basin from those of Hudson's Bay. Its area is about 200,000 square miles, or six-tenths of the whole land of the province. This region is composed exclusively of crystalline rocks, for the most part silicious, or granite-like in character, consisting of quartzite, syenite, gneiss, and other related rocks. These are broken up into ridges and mountain peaks, generally rounded in out-

line and covered with vegetation. The summits in the neighborhood of Quebec are some of them from 2,000 to 2,500 feet in height, and in other parts attain 4,000 feet or more; but the general level of this region may be taken at about 1,500 feet above the sea, although it is much less in the narrow belt which crosses the province east of Kingston. Through the hard rocks of this region run numerous bands of crystalline limestone or marble, which from their softness give rise to valleys, often with a fertile soil. The hill-sides are generally covered with little else than vegetable mold, which sustains a growth of small trees, giving them an aspect of luxuriant vegetation. But when fire has passed over these hills, the soil is in great part destroyed, and the rock is soon laid bare. In the valleys and lower parts of this region however, there are considerable areas of good land, having a deep soil, and bearing heavy timber. These are the great lumbering districts of the country, from which vast quantities of timber, chiefly pine, are annually exported, and constitute a great source of wealth to the province. These valleys are in most cases along the bands of limestone, whose ruins contribute much to the fertility of the soil. Lines of settled country running many miles into the wilderness are found to follow these belts of soft calcareous rock.

The settlements in this region are along its southern border, and at no great altitude above the sea. In the higher parts, the rigor of the climate scarcely permits the cultivation of cereals, and it is probable that no great portion of this immense region will ever be colonized, but that it will remain for ages to come covered with forests. These, if husbanded with due care, will remain a perpetual source of timber for the use of the country and for exportation; besides affording, with proper facilities for transportation, an abundant supply of fuel to the more thickly settled districts, where the forests have nearly disappeared, and where from the severity of the long winters, an abundant supply of fuel is of the first necessity. There are other reasons why this great forest region should be protected. The vegetation, and the soil which now cover the hill-sides, play a most important part in retaining the waters which here fall in the shape of rain or snow. But for this covering of soil, the rivers and mill-streams which here take their rise, would, like the streams of southern France, and of the north of Italy, be destructive torrents at certain seasons, and almost dried-up channels at others. The effect of this great wooded area in tempering the northern winds, and moderating the ex-

tremes of climate is not to be overlooked in estimating the value of the Laurentian region.....

THE EASTERN TOWNSHIPS.—Under this head, as already explained, is included the belt of hill-country south of the St. Lawrence, with the region on its south-east side, extending to the frontier, and forming a succession of valleys, which may be traced from the head-waters of the Connecticut north-eastward to the Bay of Chaleurs. It is true that the Eastern Townships, as now known, do not embrace this northeastern extension; but as it belongs to them both geographically and geologically, it may be conveniently included with them.

The area whose limits are thus defined forms about one-tenth of the province. The hills of the range which traverses it are composed, like those of the Laurentian region, of crystalline rocks: but these are softer than the greater part of the rocks on the north shore, and yield by their wearing down a more abundant soil. Some of the hills in this range attain an elevation of 4,000 feet above the sea, and the principal lakes in the valley on the south-eastern side, Memphremagog, Aylmer, and St. Francis, are from 750 to about 900 feet above the sea-level. This region is well wooded, and when cleared is found in most parts to have an abundant soil, generally sandy and loamy in character, and well fitted for grazing and for the cultivation of Indian corn and other grains. Great attention is now paid to the rising of cattle, and the growing of wool, and within the last few years the best breeds of sheep have been successfully introduced from England and from Vermont. Draining and improved methods of farming are in many parts practised, and the agricultural importance of the southern portions of this region is yearly increasing.....

THE CHAMPAIGN REGION.—The limits of the great plains of Canada have already been defined in describing those of the two preceding regions. These plains, which may be called the champaign region, occupy about three tenths of the province, and are, as we have seen, divided into two parts by a low and narrow isthmus of Laurentian country, which runs from the Ottawa to the Adirondacks of New-York. To the eastward of this division, the present region includes the country between that river and the St. Lawrence, and all between the Laurentides on the north and the Notre Dame hills on the south-east; while to the westward it embraces the whole of the province south of the Laurentian region,

including the great area lying between the Lakes Ontario, Erie and Huron, generally known as the south-western peninsula of Canada. The whole of this region, from east to west, is essentially a vast plain, with a sufficient slope to allow of easy drainage. The distance from Quebec to the west end of Lake Superior is about 1,200 miles, yet this lake is only 600 feet above the sea-level, while Lake Erie is 565 feet, and Lake Ontario 232 feet above the sea. The land on the banks of the St. Lawrence and its lakes, either near the margin, or not very far removed, generally rises to a height of from fifty to one hundred and fifty feet, and from this level very gradually ascends to the base of the hills which bound the region.

Unlike the two regions already described, these great plains are underlaid by beds of unaltered Silurian and Devonian rocks, consisting of sandstones, limestones, and shales. These are but little disturbed, and are generally nearly horizontal; but over by far the greater part of the region they are covered by beds of clay, occasionally interstratified with or overlaid by sand and gravel. These superficial strata, which are in some parts several hundred feet in thickness, are throughout the eastern division, in great part of marine origin, and date from a time when this champaign region was covered by the waters of the ocean; while throughout the western division the clays are more probably of fresh-water origin. It results from the distribution of these superficial post-tertiary strata, that the soil over the greater part of the region consists of strong and heavy clays, which in the newly cleared portions are overlaid by a considerable thickness of vegetable mould. In the eastern division, a line drawn from Quebec to Ottawa, and two others from these points, converging at the outlet of Lake Champlain, will enclose a triangular area of about 9000 square miles, which is very nearly that occupied by the marine clays. These are overlaid, chiefly around the borders of this space, by more sandy deposits, which are well seen near Three Rivers, and about Sorel. They form a warm but light soil, which yields good crops when well manured, but is not of lasting fertility. The greater part of this area however is covered by a tenacious blue clay, often more or less calcareous, and of great depth, which constitutes a strong and rich soil, bearing in abundance crops of all kinds, but particularly adapted for wheat, and was in former times noted for its great fertility. These clay lands of Lower Canada, have been for a long time under cultivation, and by repeated cropping with wheat

without fallow, rotation, deep plowing, or manure, are now in a great many cases unproductive, and are looked upon as worn out or exhausted. A scientific system of culture which should make use of deep or sub-soil ploughing, a proper rotation of crops, and a judicious application of manures, would however soon restore these lands to their original fertility. The few trials which within the last few years have been made in the vicinity of Montreal and elsewhere, have sufficed to show that an enlightened system of tillage, with sub-soil draining, is eminently successful in restoring these lands, which offer at their present prices good inducements to skilled farmers. Besides grain and green crops, these soils are well fitted for the culture of tobacco, which is grown to some extent in the vicinity of Montreal. Notwithstanding the length of the winter season in Canada, the great heat and light of the summer, and the clearness of the atmosphere enable vegetation to make very rapid progress.

To the north-east of Quebec, besides the plains which border the river, there is a considerable area of low-lying clay land, cut off from the great St. Lawrence basin by Laurentian hills, and occupying the valley of Lake St. John and a portion of the Saguenay. Here is a small outlying basin of Lower Silurian rocks, like those about Montreal, and overlaid in like manner by strong and deep clays, which extend over the adjacent and little elevated portion of the Laurentian rocks, and form a soil as well fitted for cultivation as any part of the lower St. Lawrence valley. The valley of this lake is probably not more than 300 feet above the sea; and from the sheltered position the climate is not more rigorous than that of Quebec. Several townships have within a few years been laid out in this valley, and have attracted large numbers of French Canadians from the older parishes in the valley of St. Lawrence.

The western part of the champaign region, commencing near Kingston and including all the southern portion of the western province, is the most fertile and productive part of Canada. Like the plains further eastward, its soil consists chiefly of strong clays, overlaid here and there by loam, sand, and gravel. In the natural state nearly the whole of this region supported a fine growth of timber, in great part of broad-leaved species, but presented however various local peculiarities. Thus, the banks of the Grand River from Galt to Brantford were remarkable for a sparse growth of oaks, free from underwood, and known as oak openings. These

are said to have been pasture grounds of the Indians, brought to this condition and kept in it by partial clearing, and by the annual burning of the grass. The object of this was to attract the deer who came to feed upon the herbage* The soil of these plains is a light sandy loam, very uniform in character, and generally underlaid by coarse gravel. Though fertile, and of easy tillage, this and similar soils will not support the long continued cropping without manure, which is often practiced on the clay lands of both Upper and Lower Canada.

The valley of the Thames, together with the rich alluvial flats which extend from it northward to the North Branch of Bear Creek, and southward nearly to the shore of Lake Erie, is remarkable for its great fertility, and its luxuriant forest growth. The soil is generally clay, with a covering of rich vegetable mould, and is covered in the natural state with oak, elm, black-walnut and tulip trees (*Liriodendron tulipifera*) of large size, together with fine groves of sugar-maple. Towards the mouth of the Thames, and on the borders of Lake St. Clair, is an area of natural prairie of about 30,000 acres. It lies but little above the level of the lake, and is in large part overflowed in the time of the spring floods. The soil of this prairie is a deep unctuous mould, covered chiefly with grass, with here and there copses of maple, walnut and elm, and with willows dotting the surface of the plain. Numbers of half-wild horses are pastured here, and doubtless help to keep down the forest growth. The characters of the surface are such as to suggest that it had been at no distant period reclaimed from the waters of the adjacent lake.

In no part of the province have skilled labour and capital been so extensively applied to agriculture as in western Canada, and the result is seen in a general high degree of cultivation, and in the great quantities of wheat and other grains which the region annually furnishes for exportation; as well as in the excellent grazing farms, and the quantity and quality of the dairy produce which the region affords. This western portion of the province, from its more southern latitude, and from the proximity of the great lakes, enjoys a much milder climate than the other parts of Canada. The winters are comparatively short, and in the more southern sections the peach is successfully cultivated, and the chestnut grows spontaneously.

* See on this point, Marsh's *Man and Nature*, page 137.

REVIEW OF THE NORTHERN BUCCINUMS,

AND REMARKS ON SOME OTHER NORTHERN MARINE MOLLUSKS.

PART I.

By Dr. WM. STIMPSON.

Having recently undertaken, at the request of Principal Dawson of McGill College, to make some comparisons of the fossils of the pleistocene deposits of Canada and Maine with recent species, particularly those of the difficult genus *Buccinum*, I am induced to offer the results for publication, the work having become more extended than was at first anticipated.

Genus BUCCINUM Linn.

The group of shells to which the generic name *Buccinum* was originally applied, a century ago, by Linné, has been found by subsequent investigation to contain many heterogeneous forms, and has consequently been greatly subdivided. The name has been retained for the genus typified by *Buccinum undatum*, by common consent, and, I believe, in accordance with the best rules of nomenclature. It is true that Linné's first species—that which is to be selected, as in cases where no type is distinctly specified,—is a *Dolium*. But in the case of Linné's genera, he must be considered to have indirectly specified the type, as he has expressly stated that, in his view, where it becomes necessary to divide a group, formerly supposed to be one genus, the original name must be retained for the subdivision containing the most common species; in other words, that the most common species must be considered as the type of its genus. And he must, therefore, have regarded the *undatum*, the most common of all his *Buccinums*, as the type of the genus.

The Scandinavian naturalists have generally retained the name *Tritonium* of Mueller for this genus, but Linné's name has priority by many years. *Tritonium*, as proposed, and as frequently used since, would include both the *Murex* and the *Buccinum* of Linné.

The genus is too well known to require particular description here, and few points require special remark. Among the spiral grooves and striæ or ridges with which the shell is always more or less deeply sculptured, two kinds may usually be distinguished, a large and a small kind, those of the latter being by far the more numerous, and distributed upon the surface of the others. These kinds we shall call, for convenience, the primary and secondary grooves, or

ridges, as the case may be. The difference between them is very conspicuous in *B. glaciale*. The columella has, normally three folds, an upper, middle, and lower one;—the lower one constituting the oblique inferior margin of the columella. These folds are not always distinct, but all of them may be made out in *B. tenue*. The middle fold is obsolete in most of the species, but is very prominent and tooth-like in *B. ciliatum*. The layers of the shell are very distinct in this genus, the outer coat being most frequently of a brownish color. The periostraca is generally ciliated with minute processes along the lines of growth, corresponding to their intersections with the secondary ridges.

The operculum is oval or subcircular, and may have the nucleus near the centre, or more or less approximated to the posterior (outer) margin, according to the species. On the lingual ribbon, as in all the Buccinidæ, we find three teeth in each row, the central one of which is lamelliform, with denticles on its posterior edge; while each lateral tooth has two strong hook-shaped denticles, with smaller ones between them. The denticles of the central tooth are more numerous than in *Neptunea*.

With one or two doubtful exceptions, the genus *Buccinum* is restricted geographically to the temperate and frigid seas of the northern hemisphere. More careful examination, both of the shell and soft parts of the antarctic species* referred to the genus, is required, before deciding upon their actual pertinence to it. Geologically, the history of the genus commences in the Pliocene formation. They are found in the European Tertiary deposits of that age, even as far south as the shores of the Mediterranean. They become very numerous in the Pleistocene deposits both of Europe and North America, but reach their maximum development in the existing seas.

I have endeavored to include in the following review all the species which certainly belong to the genus. As to the *B. Dalei* of Sowerby, and the *B. ovoides* of Middendorff, if we may rely upon the accuracy of the observations of Mr. Alder on the lingual dentition of the former, as detailed in Forbes and Hanley's "British Mollusca," vol. iv, p. 284, these species are not true Buccinums. Mr. Alder says, "Its tongue differs from that of *Buccinum undatum* as well as from those of the allied species of the genus *Fusus*, and makes a slight approach to that of *Mangelia*. It has a single plain

* Such as *B. antarcticum* and *B. zealandicum*.

and slightly-curved tooth on each side, and a very thin non-denticulated plate in the centre." This statement clearly indicates the existence of a distinct generic group, for which we would propose the name *Liomesus* with *Buccinum Dalei* as the type. I have specimens of *L. ovoides* from Behring's Straits.

The shells of the genus *Buccinum* are peculiarly liable to variation both in form and sculpture, and to obsolescence or erosion of the surface-markings. In the following descriptions, the normal form and markings are always given, except when otherwise distinctly stated. The identification of imperfect or worn specimens is extremely difficult in this genus.

BUCCINUM POLARE Gray.

Buccinum polaris Gray, Zoöl. of Beechey's Voy. (1839), p. 128.

Shell rather thin, ovate, turreted. Whorls 6-7, strongly and sharply bi-carinated, with the upper carina strongest, forming a prominent shoulder to the whorl. Between these two principal carinæ there are often one or two others much slighter. The longitudinal folds are regular, oblique, and about fourteen in number to each whorl; they are prominent near the suture, but become obsolete below the carina of the shoulder, on which they form tubercles. The primary spiral grooves are about thirty-five in number on the outer whorl, nearly equidistant, deep, sharply and squarely cut, and sometimes double, being divided in two by a sharp and narrow ridge. The primary ridges are flat and even, and covered with very minute secondary grooves, about six to each ridge. Aperture rather narrow, about half as long as the shell, broadest above, and somewhat contracted anteriorly; outer lip not patulous, thin and simple in our specimens. Columellar lip more deeply incurved or excavated above, less oblique and more elongated than in *B. glaciale*, and with its three folds sufficiently conspicuous. Periostraca short-ciliated on the upper whorls; perfectly smooth on the outer whorl.

Length, 2.2; breadth, 1.25 inch.

This description is taken from two specimens, probably immature, dredged by Capt. John Rodgers, of the U. S. North Pacific Expedition, in the Arctic Ocean, north of Behring's Straits. I consider them to be the *B. polare* of Gray;—at least I can find no other form agreeing as well with his description as this. Gray's specimens were from Icy Cape.

The only species with which this is likely to be confounded are

B. glaciale and *B. grænlandicum*. From the former it differs in its thin structure, shouldered whorls, and narrower aperture. It is larger and broader than *B. grænlandicum*, and the aperture is comparatively larger and more narrowed anteriorly than in that shell, which, moreover, never has shouldered whorls.

The characters given by Gray for the distinction of this species from *B. glaciale* do not hold good. That species often has whorls as "deeply striated and closely plicated" as occurs in *B. polare*.

BUCCINUM GRÆNLANDICUM Hancock.

Buccinum grænlandicum Hancock, An. and Mag. Nat. Hist. [1], xviii (1846), 329; v, 8, 9. Reeve, Conch. Icon., iii (1847), Buc., xiv, 118.

Tritonium Hancocki Moersch, in Rink's "Grænland," Tillaeg. (1857), Aftryk, 84.

Buccinum undatum Dawson, Can. Nat., ii (1857), 415.

Shell rather small, very thin, moderately elongated; spire conical. Whorls six or seven, not shouldered, regularly convex except near the suture, where they are flattened; carinæ of the body-whorl two to four, that commencing at the upper angle of the aperture being the principal one, but less prominent than in *B. glaciale*. Longitudinal folds often obsolete; when present about fifteen in number on the body-whorl, most conspicuous at the middle, where they often form tubercles on intersecting the carinæ. The spiral grooves, both primary and secondary, are much like those of *B. polare*, but are less regular, the ridges being of unequal width. Aperture short, less than one half as long as the shell, and broad, broadest above the middle. Outer lip not sinuated. Columellar lip deeply incurved above, as in *B. polare*. Periostraca thin, smooth.

Length, 1.75; breadth, 0.93 inch. Dimensions taken from a fossil specimen from Montreal.

The species was originally described by Mr. Hancock from specimens dredged in Davis's Straits. It has since been found quite abundantly in the pleistocene beds at Montreal by Prof. Dawson. The fossil specimens appear to be all of the smooth variety, in which the folds are nearly obsolete and the carinæ not tuberculated.

It is very closely allied to *B. polare*. The chief differences are mentioned under that species, but it may be added that the grooving is usually shallower and less distinct in *B. grænlandicum* than in *B. polare*. It differs from *B. glaciale* in being smaller, much

thinner, and less strongly grooved; also in having more rounded whorls and a longer columella.

Moersch changes the name of this species, because he considers the name *grœnlandicum* to have been used by Chemnitz for another species. Chemnitz however was not, in the "Conchylien Cabinet," a binomial writer, and we are not authorised by the laws of priority to take the second word of his descriptive phrase as a specific name.

BUCCINUM GLACIALE Linn.

Buccinum glaciale Linn., Syst., Nat. Ed. 10 (1758). Chemnitz. Schrift. Berlin Gesell. naturf. Freunde, vi (1785), 317; vi, 4, 5. Kiener, Icon. Buc. (1841), 6; ii, 4: Reeve, Conch. Icon., iii (1846), Buc., iii, 18. Gray, Proc. Zool. Soc. 1850, 14.

Tritonium (Buccinum) glaciale Middendorff, Malac. Rossica (1849), 168; iv. 11; excl. synonym.

Buccinum carinatum Phipps, Voy.

Tritonium glaciale O. Fabricius, Fauna Groenl. (1780), 397. Moersch, in Rink's Groenland Tillaeg (1857); Aftryk 84.

Shell thick and strong, ovate; spire regularly conical; suture not at all impressed. Whorls six or seven, flattened, usually with a very strong carina commencing at the upper extremity of the aperture and angulating the body-whorl. Sometimes there is another, less conspicuous or obsolete carina above the principal one. Folds ten to twelve, longitudinal, or very little oblique, not very strong, and often obsolete on the body-whorl. Spiral grooves as in *B. polare*. Aperture in the adult patulous, short, a little less than half as long as the shell, and broad, broader than long. Columellar lip very short, shorter than the outer lip, which reaches beyond it below, oblique, almost straight and not incurved above. Outer lip much thickened, reflected, very strongly sinuated at a point usually just above the juncture of the carina, and very much projecting or patulous below. Periostraca not ciliated, generally smooth, sometimes simply wrinkled at the crossings of the lines of growth with the spiral striæ.

Operculum sub-circular, nucleus sub-central.

Length, 3.05; breadth, 1.90 inch.

This species is very common in Behring's Straits and the Arctic Ocean north of it. In the Museum of the Smithsonian Institution there are numerous specimens collected in those seas by the author of this paper while acting as naturalist to the North Pacific Expedition. I have also specimens from Greenland, where

it was long since found by that indefatigable observer and most accurate describer, Otho Fabricius. I have a specimen from Spitzbergen, and it has been reported by Gray as having been collected at the mouth of the McKenzie River by Dr. Richardson. Midden-dorff found it in the Sea of Ochotsk. It is thus circumpolar in its distribution. It has been well named in view of its thoroughly arctic habitat. On the Atlantic Ocean it has never, as far as we are aware, been found south of Greenland on the American shores, nor south of Spitzbergen on those of Europe. In the North Pacific it reaches a notably larger size than in the North Atlantic; and Behring's Straits may be considered as its geographical headquarters, or "centre of distribution." I am not aware that it has been found in any pleistocene deposit.

It may be distinguished from the other carinated species with flattened spiral ridges by the shape of the aperture, which does not encroach upon the body-whorl within. It is less elongated and more deeply grooved than *B. Donovanii*.

Chemnitz' figure in the "Schriften" of the Berlin Society, above cited, is by far the best that has as yet been published of this species, and corresponds exactly with O. Fabricius' description. Kiener's figure represents the two-keeled variety.

BUCCINUM DONOVANI Gray.

Buccinum glaciale Donovan, British Shells, v (1799), pl. cliv. Gray, Appendix to Parry's 1st. Voy. (1824), 240. Brown, Illust. Conch. Gr. Britain (1827), xlix, 12, 13 (not of Linnæus).

Buccinum Donovanii Gray, Zool. of Beechey's Voy. (1839), 128. Gould, Inv. Mass. (1841), 304, fig. 208. DeKay, New York Fauna, v (1843), 134, pl. xxxv, 336 : Reeve, Conch. Icon. iii (1846), Buc., i, 2.

Buccinum tubulosum Reeve, Conch. Icon. iii (1847), Buc., xiii, 105.

Tritonium Donovanii Moersch, in Rink's 'Groenland' Tillaeg (1857), Aftryk 84.

Shell elongated, thick; spire long and tapering; whorls 8 or 9, convex, with an obtuse carina at the middle of the body-whorl, sometimes obsolete. This carina commences at the upper angle of the aperture. Longitudinal folds about thirteen, most distinct near the sutures, and often obsolete on the body-whorl except at the suture. Primary spiral grooves of the same type as those of *B. polare*, but broader, and always double or triple in fresh and good examples. The primary ridges are less flattened than in the other species of

the *glaciale* group; they have the usual number of fine secondary grooves upon them, but the middle groove is often somewhat deeper than the others. Aperture about two-fifths as long as the shell, and rounded. The columellar lip is more incurved above than in *B. glaciale*, and projects below to the level of the most projecting part of the outer lip. The outer lip is somewhat thickened and reflected, patulous, and broadly sinuated above about half-way between the suture and the juncture of the carina. The periostraca is very thin, and not ciliated in any of the specimens which I have seen.

The dimensions of a typical example from the Banks of Newfoundland are, length, 2.7; breadth, 1.4 inch.

Of this species I have seen several fine examples from the Banks of Newfoundland in the collection of Dr. A. A. Gould, from one of which the excellent figure in the "Invertebrata of Massachusetts" was drawn. There are specimens from the same locality in the Museum of the Smithsonian Institution, presented by the late Gen. J. G. Totten, U. S. A. Moersch mentions the species in his Greenland list.

The *B. Donovanii* is a species of very recent origin, and has not, I believe, been found anywhere in a fossil state.

It differs from *B. glaciale* in its elongated form, more convex whorls, more concave columellar lip, and more convex spiral ridges. The uncarinated variety may be distinguished from *B. undatum* by the character of the spiral grooving, the distinction between the primary and secondary grooves being far more strongly marked than in that species.

The *Buccinum Donovanii* in Mr. Bell's lists of the Shells of the Gulf of St. Lawrence * is the *Fusus Kroyeri* of Moeller.

BUCCINUM ANGULOSUM Gray.

Buccinum angulosum Gray, Zool. of Beechey's Voy. (1839), 127; xxxvi, 6.

Tritonium (Buccinum) angulosum Middendorff, Malac. Rossica. (1849), 170; iv, 10; and vii, 3, 4 (fig. xix).

Shell very short, almost globose, thick; spire short, conic; whorls five or six, slightly convex; body-whorl more or less angulated, with a carina at the middle, sometimes very strong, sometimes obsolete

* Canadian Naturalist, vol. v, p. 211, and Geol. Surv. of Canada, Report for 1858, p. 253.

Longitudinal folds about nine, not oblique, nearly obsolete at the suture, but very prominent near the middle of the body-whorl, and with broad and deeply concave intervals looking as if the shell had been pinched at these points. The primary and secondary spiral grooves are more alike than in the other carinated species preceding. The primary ridges are like those of *B. polare* and *B. glaciale* as to number and arrangement, but are much more convex; while the secondary grooves upon them are very conspicuous, four or five to each ridge, sharply cut, and nearly as deep as the primary grooves. The grooves are occasionally interrupted or waved by the intersections of the lines of growth, giving the surface a shagreened appearance. The aperture is a little more than half as long as the shell; columellar lip much incurved or concave above; columella longer than in *B. glaciale*, and projecting below as far as the outer lip does; outer lip somewhat thickened and reflected, and deeply sinuated just above the angulation of the body-whorl. Periostraca very thin; not ciliated.

Length 1.7; breadth 1.2 inch. Dimensions taken from an uncarinated specimen numbered 1777, in the Smithsonian collection.

The description is drawn up from specimens taken in the Arctic Ocean north of Behring's Straits, by the U. S. North Pacific Exploring Expedition. They occurred at a depth of twenty-five fathoms. None of them are as strongly angulated or carinated as the immature example figured by Gray; but there can be little doubt of their identity, since the polygonal whorls and deep cut grooves give the species a peculiar and unmistakable *facies*. The grooving is especially and constantly characteristic in this species, and must frequently be chiefly relied upon for its identification, since not only the carina but the folds may become obsolete or nearly so, if I have rightly judged the materials at hand.

Gray's figure is a good representation of the young of *B. glaciale*, except in the smaller number of folds, the form being exactly the same; but in his description the grooving is spoken of in such a way that he had undoubtedly before him the shell we have described above. In *B. glaciale* the secondary grooves are never conspicuous, and can scarcely be detected by the unassisted eye. Gray's specimen was from Icy Cape.

Middendorff reports this species as found on the coasts of Nova Zembla and Lapland. But I am by no means certain that his

shells were correctly identified with the Behring's Straits species. His description of the grooving does not exactly tally with that seen in my specimens, and I have met with no forms agreeing well with his figures. The question must be decided by direct comparison at some future opportunity.

The *Buccinum angulosum* may, at any rate, be considered as a truly arctic species, found as yet only in the vicinity of the northern coasts of Asia. It has not occurred as a fossil.

BUCCINUM STRIATUM Sow.

Buccinum striatum Sow., 'Records of General Science, i, 134;' Smith, Wern. Mem., viii (1839), 100; i, 9. (Not *B. striatum* of Pennant.)

Tritonium (Buccinum) ochotense Middendorff, Sibirische Reise, Zool. (1851), 235; x, 12; ix, 5.

Shell of moderate size, thick, rather elongated and appressed; whorls seven, not convex, not angulated, but in some (of the same species?) carinated by five or six of the revolving ridges which are more prominent than the others. Longitudinal folds eleven in number, not at all oblique, rather distant, and prominent, especially at the suture. Spiral ridges and grooves as in *B. glaciale*, except that the primaries are more numerous. Aperture a little less than one-half the length of the shell, rather narrow; outer lip scarcely sinuated; columella projecting beyond the anterior extremity of the outer lip.

Length 2; breadth 1 inch.

This species I have never seen. The description is founded upon the accounts given by Smith of *B. striatum* Sow., and by Middendorff of his *B. ochotense*. I have never seen the original description of Sowerby, but can find no essential difference between the form as described and figured by Smith and the *B. ochotense*.

B. striatum has the elongated, appressed form of *B. ciliatum*, with the sculpture of *B. glaciale*. Its longitudinal plications are few, straight, and strong. It differs from *B. angulosum* in its narrow aperture and flat spiral ridges, but the form which we have regarded as a carinated variety may prove to be identical with *angulosum* and not with *striatum*, when the sculpture is more carefully examined.

The shell first occurred as a fossil in pleistocene beds of the Clyde, where it was found by Mr. Smith of Jordan Hill. It has as yet been found living only in the Sea of Ochotsk, by Dr. Middendorff.

The name of this species ought not to be changed on account of its prior use by Pennant, for the *B. striatum* of this latter author is only a variety of *B. undatum*.

BUCCINUM CILIATUM O. Fabr.

Tritonium ciliatum O. Fabr., Fauna Groenlandica (1780), 401. Moersch, in Rink's 'Groenland,' Tillaeg (1857), Aftr. 84.

Buccinum ciliatum Moeller, in Kroyer's Tidsskrift, iv (1842), 85. Reeve, Conch. Ic., iii (1846), Buc., v, 29.

Buccinum cyaneum Hancock, An. and Mag. Nat. Hist. [1], xviii (1846), 328. (Not of Bruguière.)

Buccinum Mölleri Reeve, Conch. Ic. iii (1846), Buc., Errata.

Tritonium (Buccinum) tenebrosus, var. *borealis* Middendorff, Malac. Rossic. (1849), 162; iii, 7, 8. (Not *B. tenebrosus* of Hancock.)

Shell rather small and solid, becoming very thick with age, elongated-oval, or sub-elliptical, appressed. Sutures not impressed. Spire short; body-whorl elongated, and constituting seven-tenths of the length of the shell. Whorls not convex, not carinated, plicated; longitudinal folds thirteen to eighteen in number, more or less oblique, variable in number and prominence, but never entirely obsolete at the suture. The primary spiral ridges are narrow and distant, about thirty in number on the lower whorl, but are somewhat variable in strength and distance. They are sometimes double or divided in two by a groove. The secondary ridges alternate with the primaries singly or by groups of two, three, or four; they are only to be distinguished from the primaries by being less prominent, and occupying the depressions constituting the primary grooves. In some specimens the primary and secondary ridges and grooves can scarcely be distinguished from each other. Aperture elliptical, elongated, and narrow, a little more than half the length of the shell, not patulous, but somewhat canaliculated and projecting below; outer lip scarcely at all sinuated. Columella with a distinct tooth or projection near its anterior or lower extremity. This projection corresponds to the second fold of the columella seen in several other species such as *B. tenue* and *B. undatum*, but it is more tooth-like than in any species of the genus, and constitutes an important and easily-recognised specific character. Periostraca ciliated.

Operculum marked on upper surface with regular and prominent lamellæ of growth; nucleus situated at a point half-way between

the centre and the outer edge ; outer margin sinuated opposite the nucleus ; scar of lower surface correspondingly sinuated ; marginal limb around the scar considerably thickened.

Length, 1.54 ; breadth, 0.81 inch. These dimensions are those of a specimen from Behring's Straits.

Although *B. ciliatum* is the most distinct and well marked form in the genus, it is by no means a common species, and, when found, has been frequently referred to other quite different species, for want of attention to its peculiar characters, although these were originally very well described by Otho Fabricius. The appressed form of the shell, narrow, somewhat canaliculated aperture, and the tooth on the columella are its prominent characters. Hancock speaks of the tooth in the description of his *B. cyaneum*, and Middendorff has it distinctly marked in his figure of *tenebrosus* ; so that there can be no doubt with regard to the shell meant by those authors.

On the other hand the name *ciliatum* has been applied to a very different species, the *Humphreysianum* of Bennett, by Dr. Gould and others.

We have the true *B. ciliatum* in the Smithsonian Collection, from Greenland, where it was originally found by O. Fabricius. Hancock reports it from Davis' Straits ; a specimen from the Newfoundland Banks is in the collection of Dr. Gould ; and I have received it from the coast of Nova Scotia through the kindness of my friend, Mr. J. R. Willis of Halifax. I have it also from Behring's Straits and the Arctic Sea north of it, collected by Capt. John Rodgers of the North Pacific Expedition ; and specimens from the mouth of McKenzie's River were sent to the Institution by Mr. R. W. McFarlane. I am not aware that it has ever been found in a fossil state.

BUCCINUM PLECTRUM, nov. sp.

Shell rather large and thin, elongated ; spire produced ; sutures less deep than in *B. tenue* ; whorls seven or eight, regularly convex, or slightly appressed, less gibbous or shouldered at the sutures than in *B. tenue*, and not carinated. Longitudinal folds very numerous, about nineteen, as broad as their interspaces, and most prominent near the suture ;—they are curved in a somewhat sigmoid form, and are sometimes, though rarely, interrupted, or have an intervening fold about the middle of the whorl. The striation of the surface

has considerable resemblance to that of *B. glaciale*, the primary grooves being deep cut, with the intervening ridges depressed. But the grooving is far less regular than in that species; the primary grooves are more crowded near the suture, and the ridges less flattened. The secondary grooves, on the surface of the primary ridges, are usually as fine as in *B. glaciale*, but often one or more of them becomes deeper, making the sculpture resemble more that of *angulosum*. Aperture oval, less than one half the length of the shell, and narrower than in *B. tenue*. The columella does not project beyond the level of the anterior part of the outer lip, but rather falls short. The columella shews the usual three folds, but the middle fold being nearly longitudinal and parallel to the lowermost fold, the latter cannot be seen in a front view, but it is easily seen in an edge view of the columella, (in broken specimens of the shell,) separated from the marginal middle fold by a longitudinal sulcus. The first and second (uppermost and middle) folds are separated by a broad deep sinus. Periostraca thin, smooth, not ciliated.

Length, 2.23; breadth, 1.2 inch. Another specimen is 2.5 inches long, proportionally more slender.

It may be described in brief language by saying that it has nearly the form and plaits of *B. tenue* with a striation of the *glaciale* type. It evidently approaches nearest to *tenue*, but besides the difference in the striation, the much greater regularity of the longitudinal plaits will serve to distinguish it.

Of this species there are two specimens in the museum of the Smithsonian Institution, which were dredged alive in twenty to thirty fathoms in the Arctic Ocean north of Behring's Straits, by Capt. John Rodgers, U. S. N., while on the North Pacific Exploring Expedition.

I have, among a number of fossil Buccinums kindly loaned by Dr. Packard, two imperfect specimens, probably of this species, from the pleistocene beds of Portland, Me. They differ from the Behring's Straits specimens only in the following particulars. The shell is broader and thicker, with fewer (thirteen) longitudinal folds, none of which are interrupted;—thus approaching *B. undulatum* in these respects. The primary ridges are more convex, and are alternately wider and narrower. The secondary grooves are rather less numerous.

These differences may prove to be specific, when perfect spe-

cimens of both forms can be obtained in sufficient numbers. If so, I would suggest the name *Buccinum Packardi* for the Portland form. It is easily distinguished from *B. undulatum* by the flattening and finer striation of the primary ridges, which are also much broader than the corresponding grooves.

I have also a fragment of the form *Packardi* from the Pleistocene of New Brunswick, sent by Mr. G. F. Matthew.

BUCCINUM TENUE Gray.

Buccinum tenue Gray, Zool. of Beechey's Voy. (1839), 128; xxxvi, 19. Reeve, Conch. Ic. iii (1846), Buc., iv, 27.

Buccinum scalariforme Beck, in Kroyer's Tidsskrift, iv (1842), 84. Moersch, in Rink's 'Groenland,' Tillaeg, (1857), Afr. 84. Packard, Canadian Naturalist, viii (1863), 417. Dawson, Canadian Naturalist [2], ii (1865), 88.

Tritonium (Buccinum) tenue Middendorff, Malac. Rossica (1849), 172; vi, 5, 6.

Buccinum tortuosum Reeve, Conch. Ic., ii (1847), Buc., xiv., 115 (malformation).

Shell of moderate size, thin or only moderately thick, elongated, turreted; spire produced; suture deep; whorls subcylindrical, not carinated, but convex or shouldered near the suture. Longitudinal folds very numerous, more so than in any other species, between twenty-five and thirty in number, mostly arising at the suture, but sometimes interpolated at the middle of the whorl. The folds, between which the interpolated ones occur, are often interrupted before completing their normal length. There are no primary ridges or grooves. The secondary grooves are exceedingly numerous, almost microscopic, but plainly conspicuous, evenly distributed and crowded, sharp-cut, and minutely waved or shagreened by the lines of growth. Sometimes deeper and shallower grooves alternate with each other, either singly, or by two or three of the shallow ones to one of the deeper kind; the difference never, however, being so great as to suggest a division of the grooves into primaries and secondaries. Aperture a little more than two-fifths the length of the shell, short and broad. Columella projecting beyond the outer lip, and having its three folds rather conspicuous, the middle one being generally quite prominent, more so than the upper one, but not tooth-like. Outer lip thickened, slightly patulous and projecting below in full grown specimens; and very little sinuous, the sinus

being also very near to the suture. The whorls are pretty sharply contracted below as well as above, so that the siphonal canal at the anterior extremity of the shell projects from the whorl with more than usual abruptness. Periostraca very thin, never ciliated.

Operculum oval, nucleus close to the outer margin.

Length, 2.1; breadth, 1.05 inch; from a pleistocene specimen from Hudson's Bay. A recent specimen, from Disco Island measures 2.5 inches in length.

A young individual from Behring's Straits, No. 1775 of the Smithsonian Collection, varies from the type in form, being somewhat appressed, with a much narrower aperture.

The species is easily distinguished from all others by its numerous and frequently interrupted or interpolated plaits, and its minute and crowded but distinct transverse grooves.

This is a common Greenland species, and is reported from the coasts of Nova Zembla and Lapland by Middendorff. I have before me specimens from Spitzbergen; from the vicinity of Behring's Straits, collected by the U. S. North Pacific Expedition; from the north-western coast of Greenland, and from Disco Island, collected by Dr. Hayes; and from Labrador by Dr. A. S. Packard. As a pleistocene fossil, I have it from the eastern coast of Hudson's Bay collected by Mr. Drexler, from Labrador by Dr. Packard, and from Rivière du Loup, Lower Canada, by Professor Dawson. At the present epoch it is a circumpolar species, rarely if ever found living south of the Arctic circle.

BUCCINUM UNDATUM Lin.

Buccinum undatum Lin., Syst. Nat. Ed., x (1758). Forbès & Hanl., Brit. Moll., iii (1853), 401; cix, 3-5 and L.L., fig. 5. Reeve, Conch. Icon. iii (1847), Buc., i, 3.

Tritonium undatum Mueller, Zool. Dan., ii (1788), 12; pl. 1.

Buccinum striatum Pennant, Brit. Zool., 4th Ed., iv, 121; lxxiv, 91.

Shell large, thick, ovate; spire of moderate length; suture not impressed, or, rarely, slightly impressed. Whorls seven, not carinated. Longitudinal folds about fourteen, oblique, sometimes obsolete, but always distinct in young specimens. Primary spiral ridges usually about twenty in number, prominent, rounded, and narrower than the intervening broadly concave primary grooves;—they are generally equidistant in one and the same specimen, except where they become gradually more crowded on the lower part of the lower

whorl; but they vary considerably in the distance apart, in different specimens. Sometimes the primary ridges become much more numerous, and are unequal,—alternately larger and smaller. Secondary ridges somewhat variable in size, but uniformly distributed over the primary ridges and grooves,—about six to eight to each ridge and its corresponding groove. The striation and grooving varies much in prominence, but the normal characteristics and relative proportion can always be traced, even in specimens somewhat worn. Aperture nearly one-half as long as the shell; columellar lip not incurved or very little excavated into the whorl; columella usually projecting beyond the level of the anterior part of the outer lip. Periostraca ciliated; hair-like processes long in good half-grown specimens, longest in those specimens which have less prominent folds and striæ. On some specimens the periostraca is smooth, or scarcely ciliated.

Operculum oblong-oval, with the nucleus very near to the outer margin.

Length, 4.1; breadth, 2.15 inch, from a specimen from the east coast of England.

The differences between this and the *B. undulatum* will be noticed under that species.

As an existing species, the *Buccinum undatum* has a more restricted geographical range than most others of the genus, being found only on the Western coasts of Europe, from Southern Norway to Portugal. * Like its intimate representative, the *B. undulatum*, it does not extend into the Arctic regions, and is entirely wanting in the North Pacific fauna. Certain Asiatic shells, referred to it by Middendorff, belong properly to other species, though much resembling this in some of their characters. The species of *Buccinum* when appearing under diseased, abnormal or imperfect conditions, are very apt to simulate each other.

The *Buccinum undatum* is reported to occur in the pliocene and pleistocene tertiaries of many localities in Europe. It will require, however, much more critical study to determine whether the shells so occurring are correctly referred to this species. There is little doubt however that some of the shells found in the English crag belong to it.

* Moerch includes the *undatum* in his list of Greenland shells, but refers to Middendorff's "Beiträge zur einer Malacologia Rossica," p. 482, pl. iv, fig. 3. This figure seems rather to represent the *undulatum*.

I have not had an opportunity of examining a specimen of the *Buccinum acuminatum* of Broderip, described and figured in the "Zoological Journal," vol. v (1850), p. 44; pl. iii, figs. 1, 2. Forbes and Hanley, in their "British Mollusca," consider it to be an abnormal form of *B. undatum*.

BUCCINUM UNDULATUM Moeller.

Buccinum undatum Greene, Catalogue of the Shells of Massachusetts (1833). Gould Inv. Mass. (1841), 305. DeKay, New York Fauna, v (1843) 130; pl. vii, 161. Dawson, Can. Nat. [2], ii (1865), 88.

Buccinum undulatum Moeller, in Kroyer's Tidsskrift, iv (1842), 84.

Buccinum labradorens Reeve, Conch. Icon., iii (1846), Buc., i, 5. Packard, Can. Nat., viii (1863), 416.

Tritonium undulatum Moersch, in Rink's 'Grønland' Tillaeg (1857), Afr. 84.

It is not often that two species of shells can be found, the differences between which are more difficult to define than those of the common whelks of the European and North American shores of the Atlantic. Existing as they both do in vast numbers and occupying a very extensive range in station,—from between tide-marks to a depth of more than fifty fathoms on all kinds of ground,—it is not surprising that we find considerable variation among the very numerous specimens which come under our notice, and that the varieties of the two forms, which occur under similar conditions should approach each other closely. Yet it is not at all difficult in most cases, for one familiar with these forms to tell at a glance whether an adult specimen came from the eastern or western side of the ocean. There is a *facies*, difficult to describe, which makes the forms easily recognizable. But specific, tangible differences are hard to find. After careful comparison, I have detected none in the soft parts, nor in the lingual dentition, the central tooth in both having six denticles, and the lateral tooth four. Nor can we find differences in the younger half grown shells. With the adult shells I have met with more success, and will endeavor to describe the distinctive features.

The whorls are more convex next to the suture in *undulatum* than in *undatum*, and the suture is consequently deeper. In *undulatum* also the body-whorl is proportionally broader, and the spire usually shorter; the aperture is smaller, more circular, and conspicuously more arched within or excavated into the body-whorl at the upper part of the inner lip. In *undulatum* the sinus

of the outer lip is rather narrow, deep, and near the suture; while in *undatum* it is broader, shallower, and further forward, nearer the middle of the lip. In *undatum* the surface within the aperture is always white or chocolate-colored, while in the American species, as Dr. Gould* has already pointed out, it is often saffron colored. The columella is shorter (less projecting below) in the American shell than in the European. Finally the ciliation of the periostraca in *undulatum* is short and sparse, never long and furry as is commonly the case in good specimens of *undatum*.

Our shell never reaches the size nor the number of whorls of the European form. I have one specimen from Labrador four inches in length, but the average size of adults is much less than the average of foreign shells. A good example from Maine measures 3 inches in length, and 1.8 inch in breadth.

From President Dawson, I have received specimens from the St. Lawrence River, which were taken from water somewhat *brackish*. The influence of an uncongenial element is plainly perceptible in them. They are much thinner and smoother than normal examples, but would not be confounded with any of the smooth species described elsewhere in this paper, such as *B. cyaneum*; for the character of the striation, though but faintly indicated in these specimens, is still the same as that of the typical examples.

There can be but little doubt that our shell is the same as the *undulatum* of Moeller, as it agrees in all respects with that author's description. The figure of Reeve is good, but his description is erroneous in the expression "whorls transversely very finely striated." Our shell ranges further north than the European *undatum*, being adapted to a colder climate. Its northern limit is Southern Greenland, where, however, it is rare. Its southern limit, as far as ascertained, is on the sea-bottom off the coast of New Jersey, in N. lat. 40°, W. long 73°, where it was dredged by Capt. Gedney, U. S. N., in thirty-two fathoms, sandy bottom. Like many other cold-water species it lives there in the polar under-current which flows beneath the gulf stream, and in a contrary direction. I have also specimens from Labrador, Newfoundland, the Gulf and River of St. Lawrence, Nova Scotia, Grand Manan, the coast of Maine, Massachusetts Bay, Cape Cod, and Nantucket.

* "Its golden mouth, too, which, is not found in foreign shells, renders it a beautiful shell." Gould, *Inv. Mass.*, p. 306.

As a pleistocene fossil we have it from Maine, collected by Dr. Packard; from Rivière du Loup, Canada, by Principal Dawson; and from Labrador, by the students of William's College.

Certain figures of Middendorff are good representations of our shell. But I am unwilling to regard it as an inhabitant of Lapland and the sea of Ochotsk, without actual comparison of specimens.

The great variety of station inhabited by this species has been already alluded to.

In conclusion, it may be remarked that although we have good grounds for considering the common whelks of Europe and North America, as they exist at the present day, to be good and distinct species, it is by no means improbable that evidence may be found in the more recent tertiary deposits to prove them to have been derived from a common ancestry. At a former geological epoch, it is not improbable that, owing to the different geographical conditions, the climates of the two sides of the North Atlantic were far less diverse than at present, when we find a very equable water temperature on one side, and a variable one on the other,—causes which must have their effect upon animal life in the lapse of centuries. The question with regard to these *Buccinums* will probably be settled with greater ease than in most other cases, since the material is abundant, and only requires to be collected with the object in view. Specimens from the pleistocene deposits of Greenland, Iceland, the Faroe Islands, etc., will have special interest.

At present it seems proper to regard all forms as specifically distinct which present constant differences, whatever may have been the origin of these differences.

BUCCINUM CYANEUM Brug.

Tritonium undatum O. Fabr., Fauna Groenlandica (1780), 395 (not of Mueller).

Buccinum cyaneum Bruguière, Encyc. Meth., Vers., i (1792), 266. Beck, in Kroyer's Tidsskrift, iv (1842), 84. Reeve, Conch. Icon., iii (1846), Buc., ix, 69.

Buccinum boreale Leach, Jour. de Phys., etc., lxxxviii (1819), 464. Gray, Zool. of Beechey's Voy. (1839), 128; Brod. & Sow., Zool. Journ., iv (1829), 375.

Buccinum Humphreysianum Moeller, in Kroyer's Tidsskrift, iv (1842), 85 (not of Bennett).

Buccinum hydrophanum Hancock, Ann. & Mag. Nat. Hist. [1], xviii (1846), 323; pl. v, 7. Reeve, Conch. Icon., iii (1847), Buc., xiii, 103.

Buccinum sericatum Hancock, Ann. & Mag. Nat. Hist. [1], xviii (1846), 328; pl. v, 6.

Buccinum tenebrosus Hancock, Ann. & Mag. Nat. Hist. [1], xviii (1846), 327; pl. v, 1, 2. (?)

Buccinum undulatum Hancock, Ann. & Mag. Nat. Hist. [1], xviii (1846), 327 (not of Moeller).

Tritonium (Buccinum) tenebrosus Middendorff, Malac. Rossic. (1849), 160; vi, 9, 11.

Tritonium groenlandicum Moersch, in Rink's 'Groenland' Tillaeg. (1857), Afr. 84.

Buccinum undatum Dawson, Canadian Naturalist [2], ii (1865), 88 (not of Linn.)

Shell of moderate size, rather slender when full grown, thin and usually of a light, fragile structure; spire regularly tapering, pointed, and produced in old specimens; suture not deep. Whorls six to eight, not very convex, flattened near the suture, and generally much smoother than in any other species;—they are neither carinated nor angulated except in occasional instances by the prominence of certain ones of the primary striæ. Longitudinal folds, when they exist, straight, not oblique, ten to fifteen in number, extending very little below the suture. Primary spiral ridges rounded, not flattened, very narrow and distant, about fourteen in number on the lower whorl, often entirely obsolete, but sometimes sufficiently prominent to form slight carinae, in which case they do not project considerably from the proximate surface of the shell, but seem to form angles rather than ridges. Secondary ridges, when present, one-third as broad as the primaries, and distributed upon them and upon their interspaces by about five to each ridge and groove taken together. On the upper whorls in old specimens we sometimes see the secondary striæ regularly and closely arranged with no trace of the primaries. But the characteristic primary ridges as well as the secondaries, may almost always be perceived on the body-whorl in adult specimens. Occasionally, in young individuals, the primary ridges are much more numerous than in the ordinary form, and may be even broader than the interspaces. Aperture two-fifths as long as the shell in the adult, (half as long in immature specimens,) and rather narrower than in *B. undatum*; columella rather short, smooth; outer lip generally neither thickened nor reflected, and with but a very slight sinus above the middle. The outer lip is sometimes thickened in old and heavier specimens, but never reflected. Colors bright but variable,

usually bluish with chestnut-brown revolving lines, or series of spots, or patches; sometimes brown with white spots. Periostraca smooth or short-ciliated.

Operculum elliptical; nucleus distant from the outer margin about a fifth of the total width. Central tooth of the lingual ribbon with five equal denticles; lateral tooth with three.

The dimensions of an adult specimen from Northern Greenland are, length, 2.3; breadth, 1.3 inch. The species is however very variable in size, dwarf specimens with the full number of whorls frequently occurring. There is a slender dwarf form (*Humphreysianum* Moell., non Bennett) occurring in the Greenland seas, which, with six whorls, is only one inch in length. The specimens of the ordinary form, of that length, would have but four whorls. Yet all the dwarfs have the characteristic striation, and must, with little doubt, be referred to the same species.

B. cyaneum may be distinguished from the young of *B. undatum* and *B. undulatum* by the delicacy of the primary transverse ridges and especially by the absence or obsolescence of the folds on the columella; from *B. plectrum* by the shortness of the longitudinal folds, and the coarser secondary ridges; from *B. Humphreysianum*, by the more slender shell, less convex whorls, and less numerous and less crowded primary ridges; and from *B. groenlandicum* by want of the regular, parallel and sharp cut primary grooves which characterise that species in common with others of the *glaciale* group. I have mentioned the *B. groenlandicum*, though not an allied species, because the primary ridges of the *cyaneum* in some specimens might be mistaken at the first glance for the carinæ of that species, both shells being of a thin and delicate structure.

The *cyaneum* is a North Atlantic species, ranging as far into the arctic regions as exploration has yet extended. Southwardly its geographical limits reach but little beyond the Arctic circle on the shores of either continent. It is abundant in all parts of the seas of Greenland, even to Port Foulke on the north-western coast, from which place I have specimens brought home by Dr. I. I. Hayes of the American Arctic expedition. Hancock reports it from Davis Straits, its southern limit, as an existing species, on our coast. It is common on the northern coast of Norway and Lapland. As a fossil it occurs in the Pleistocene of Rivière-du-Loup, Canada, in fine condition, and as large as the specimen from northern Greenland, the dimensions of which are given above.

For several of these fossil specimens I am indebted to President Dawson.

Moersch considers the species to be the '*Buccinum novum groenlandicum*' of Chemnitz, and has adopted the name *groenlandicum* for it, as already mentioned under the head of *B. groenlandicum* Hancock.

BUCCINUM SIMPLEX Midd.

Tritonium (Buccinum) simplex Middendorff, Sibirische Reise, Zool., i, 234.

As I have never seen a specimen of this unfigured species, which appears to be distinct, I can do no better than quote Middendorff's description, which is as follows:

"Testa purpureo-fusca, solida, ovato-conica; anfractibus convexis, striolis æqualibus longitudinalibus minutissimis, oculo nudo vix conspicuis, undulatis, confertissime ornatis; columella distincte voluta, rugositate spirali externe munita; canali brevi, incurvo, apice truncato; epidermide tenui, tenace, fusco-viridescente. Anfract. numer. 6 ad 7."

Middendorff further remarks that the species is very similar to "*Trit. tenebrosus*" (*cyaneum* ?)* in form and color, but is as thick and heavy as perfect specimens of *B. undatum*; and that it is especially characterised by the uniformly crowded transverse striae which cannot well be distinguished by the naked eye, and of which there are from forty to ninety on the penultimate whorl. And that the entire want of ciliation on the periostraca, the crooked canal, and the unplicated whorls will give us the means of distinguishing it. "The outer lip is thick, and often reflected, with a somewhat expanded margin. The columella and inner lip are entirely analogous to those of *Tritonium undatum* and *tenebrosus*."

The dimensions given are, length sixty-one; breadth thirty-two millimetres.

Found at Schantar Island, in the sea of Ochotsk.

Judging from the description, this shell must be closely allied to the large thick and smooth variety of *B. cyaneum*. But the transverse striae, which are evidently of the secondary kind, are

* Middendorff includes two species in his *T. tenebrosus*, viz. *B. cyaneum* and *B. ciliatum*.

apparently much more numerous than in that species, the mouth more patulous, and the columella more distinctly folded.

BUCCINUM TOTTENII, nov. sp.

Buccinum ciliatum Gould, Inv. Mass. (1841), 307 (in part). Dawson, Can. Nat., ii (1857), 415, pl. vii, fig. 5 (not of O. Fabr).

Shell of moderate size, white, of a light and thin structure; spire acute; suture impressed, whorls seven, regularly convex, neither carinated nor angulated. Longitudinal folds about twenty-two in number to each whorl, very regular, straight, not at all oblique, and about equaling their interspaces in width. These folds are prominent on the spire, but usually obsolete on the body-whorl, except occasionally at the suture. The transverse striation is somewhat as in *B. undatum*, but sharper and more regular, and the grooves are narrower and more deeply cut. The primary ridges are very numerous and crowded, less projecting than in *B. undatum*, but differing among themselves in strength, the narrower and less prominent ones usually alternating by threes or fours with the stronger ones. The primary grooves are much narrower than the corresponding ridges. The secondary grooves are few in number, occurring for the most part only on the greater ridges, and, as usual in the *undatum* group; they are not easily distinguished from the smaller primaries. Aperture rather broad, and half as long as the shell; outer lip thin, effuse, and projecting below, and with its superior sinus very broad and shallow, or obsolete; folds of the columella little prominent. Color within the aperture white or pale yellowish. Periostraca light yellowish, short-ciliated with triangular fimbriæ at the intersections of the lines of growth with the transverse striæ.

Length, 2.12; breadth, 1.3 inches.

Several specimens of this species, from the Banks of Newfoundland, are in the museum of the Smithsonian Institution, donated by the late Gen. Totten of the United States Engineer corps, to whom I have dedicated it, in recognition of his early investigations in the conchology of our Eastern coast. According to Principal Dawson, this species occurs in the Pleistocene beds of Montreal.

It is allied to *B. Humphreysianum*, but differs in its plicated and more convex whorls, deeper transverse sculpture, and want of color. It might be taken for a thin and delicate form of *B. undatum*, but is easily distinguished by the number and straightness

of the longitudinal plications of the spire-whorls, the more numerous and sharply-cut transverse ridges, and the wider mouth. From *B. ciliatum* it differs very much, both in shape, and in the want of a tooth-like fold on the columella.

BUCCINUM HUMPHREYSIANUM Bennett.

Buccinum Humphreysianum Bennett, Zoöl. Journ., London, i (1825), 398, pl. xxii, upper figures. Forbes and Hanley, Brit. Moll., iii, 410; pl. cx, 1.

Buccinum ventricosum Kiener, Iconography, Buc. (1841) 4, pl. iii. 7, (not of Lam.)

Buccinum ciliatum Gould, Inv. Mass. (1841), 307; fig. 209. Reeve, Conch. Icon. iii (1846), Buc. i. 1 (not of O. Fabr.)

Tritonium (Buccinum) Humphreysianum Middendorff, Malac. Rossic. (1849), 163 (syn. partim excl.)

Tritonium Humphreysianum? Moersch, in Rink's 'Groenland' Tillæg, (1857) Afr. 84.

Shell rather below the medium size, very thin, translucent, pale, brownish, with fulvous or reddish markings sometimes obsolete. Spire conic; whorls 7, somewhat flattened above and regularly convex below, so as to be faintly shouldered above the middle. They are neither plicated, carinated nor angulated, and the surface is much smoother than in most species of the genus. The transverse striation is of the same type as that seen in *B. undatum*, etc., but far less prominent. The primary ridges are to be distinguished from the secondaries only at the obsolete angle or shoulder of the whorl, where there are generally two or three small ridges on each side of the more prominent ones and the corresponding sulcus. On the middle and lower part of the body-whorl, where the transverse ridges are for the most part equal in size and strength, and equal to the intervening grooves, the grooves are crossed by well-marked though microscopic lines of growth.

The aperture is almost one-half the length of the shell, and about three-fifths as broad as long. The outer lip is very little thickened and scarcely at all projecting below, and it has no sinus at the middle. Columella like that of *B. undulatum*. Periostraca ciliated.

The dimensions of a specimen from the Newfoundland banks are, length, 1.45; breadth, 0.82 inches.

This species is reported from the seas of Ireland, by Bennett; Zetland, by Forbes and Hanley; Lapland, by Middendorff; Greenland, with a query, by Moersch; Newfoundland banks, by Gould;

and the gulf of St. Lawrence, by Mighels. In the Smithsonian museum there are some bleached specimens, found in the Arctic ocean, near the mouth of the McKenzie river, by Mr. R. W. McFarlane.

It may be recognised by its thin structure, superiorly flattened whorls, and the total absence of plications in connection with an obsolescent transverse striation of the type seen in the *undatum* group.

In the following table I have endeavoured to present an analytical synopsis of the species of *Buccinum* here treated of, * as an aid to their determination. In a genus where almost every specific character is subject to great variation, and where the species must be recognized rather by the gross amount of the characters than by the prominence of particular ones, this is, as may be easily understood, a very difficult matter. Such a synopsis is here only useful for the determination of the specific relations of perfect and well characterised specimens,—normal or typical examples of the species. Abnormal forms, imperfect specimens, etc., must be compared with the full descriptions preceding.

* Of the various Arctic *Buccinums* which were described during the early part of the present century (1819 to 1839), by the English writers, Leach, Gray and others, without much critical comparison or reference to each other's labors, I believe I have correctly identified and placed in the synonyme all but the *B. boreale* of Broderip and Sowerby, in the "Zoological Journal" of London, vol. iv. (1829), p. 375, which has baffled all my attempts at proper reference. It may be a variety of *B. angulosum* or of *B. cyaneum*. The following is their description in full :

"*B. t. tenui*, ovato-fusiformi, anf. ventricosis striatis ; ultimo sutura simplici ; caeteris suturam versus plicatis ; apertura patula, labio superne sublobato ; epidermide fuscâ, crassâ ; long 2.6 ; lat. 1.6 poll.

Habitat in Oceano Boreali.

The habit of the shell is not unlike that of *B. undatum*, but it differs from it in many points, especially in the form of the aperture and thinness of the shell. In young specimens the epidermis is so strong, that in drying it breaks the delicate edge of the lip. From Kamtschatka."

SYNOPTIC TABLE OF THE SPECIES OF BUCCINUM.

A. Body: whorl angulated or carinated.

a. Primary transverse ridges flat; secondary ridges inconspicuous.

1. Shell thin; aperture not patulous; outer lip not sinuated.

* Whorls shouldered; aperture broadest above.

** Whorls scarcely shouldered; aperture broadest below.

2. Shell thick and strong; aperture patulous; outer lip sinuated.

* Shell elongated.

** Shell ovate.

b. Primary transverse ridges convex; secondary grooves very distinct.

B. Body: whorl not angulated.

a. Aperture narrow.

1. Primary ridges flat.

2. Primary ridges convex; a strong, tooth-like plait on the columella.

B. POLARE.

B. GRÆNLANDICUM.

B. DONOVANI.

B. GLACIALE.

B. ANGULOSUM.

B. STRIATUM.

B. CILIATUM.

6. Aperture broad.

1. Longitudinal folds numerous, often interrupted, or interposed.

* Primary ridges flat.

** Primary ridges obsolete; secondaries conspicuous, crowded.

2. Longitudinal folds not interrupted or interposed.

* Shell thick and coarsely striated.

† Sinus of outer lip near the suture, columella short.

†† Sinus of outer lip near the middle, columella projecting.

** Shell finely striated, usually thin.

† Secondary ridges easily distinguished from the primaries, which are often obsolete.

|| Columella distinctly folded.

||| Columella smooth, not distinctly folded.

†† Secondary ridges confounded for the most part with the primaries.

|| Longitudinal folds conspicuous.

||| Longitudinal folds obsolete.

B. PLECTRUM.

B. TENUE.

B. UNDULATUM.

B. UNDATUM.

B. SIMPLEX.

B. CYANEUM.

B. TOTTENI.

B. HUMPHREYSIANUM.

A PROVISIONAL CATALOGUE OF CANADIAN CRYPTOGAMS.

The Editor of this journal is collecting material towards the compilation of an annotated catalogue of Canadian plants which he hopes to be able to publish in the next volume. With a view to direct attention to the subject, he now prints so much of that material as relates to cryptogams; and takes opportunity to invite contributions towards the proposed work from all the botanical readers of the *Naturalist*. In all orders, save ferns and allied plants, these lists are of course very incomplete, in view of which, and to facilitate reference, the genera and species have been arranged alphabetically. Should sufficient material accumulate, it is intended hereafter to treat the fungi, lichens, mosses, and liverworts, as well as the phenogams, after the same manner as the ferns, and to add descriptions to those few Canadian plants which are not included in the last edition of Gray's Manual.

Cryptogamic plants are classified in Rev. J. M. Berkeley's "Introduction to Cryptogamic Botany," as follows:

CLASS I. THALLOGENS, (Lindley,) comprising ALLIANCE I. ALGALES (*Seaweeds*), ALLIANCE II. MYCETALES, including *A* Fungales (*Fungi*), *B* Lichenaes (*Lichens*). CLASS II. ACROGENS, (Lindley), comprising ALLIANCE III. CHARACEALES (*Charas*), ALLIANCE IV. MUSCALES (*Liverworts and Mosses*), ALLIANCE V. FILICALES (*Filicoid plants*).

ALLIANCE I. ALGALES, Lindley.

Having little to add to what has already appeared in the *Naturalist*, the editor would for the present merely refer to the contributions of Rev. A. F. Kemp:—those on fresh-water algæ, in vol. iii, 1858, and on marine algæ, in vols. v, 1860, and vii, 1862.

ALLIANCE II. MYCETALES, Berkeley. *A Fungales*, Lindley.

This list of fungi is very imperfect, and is capable of almost indefinite extension. It comprises the collections of Dr. W. P. MacLaggan, whose species were determined by Rev. J. M. Berkeley, and those of the Editor, most of whose passed under the eye of Rev. Dr. Curtis of North Carolina. Both collectors confined themselves chiefly to the microscopic forms. Mr. Berkeley estimates the number of good species in Britain at nearly 2500.

Æcidium cimicifugatum.

Æcidium Claytoniatum.

Æcidium Compositarum.

Æcidium crassum.

Æcidium Draconturatum.

Æcidium hypericifoliæ.

Æcidium Geranii.

Æcidium Grossulariæ.

- Æcidium laceratum.*
Æcidium laminatum.
Æcidium lauratum.
Æcidium leucospermum.
Æcidium Orobi.
Æcidium Pini.
Æcidium podophyllum.
Æcidium Ranunculacearum.
Æcidium sambuciatum.
Æcidium Thalictri.
Æcidium Violarum.
Agaricus salignus.
Agaricus variabilis.
Arcyria punicea.
Aregma mucronatum.
Aregma obtusatum.
Ascobolus Trifolii.
Asteroma pomigena.
Bovista plumbea.
Calvaria cristata.
Calvaria abietina.
Cantharellus crispus.
Capnodium elongatum.
Cenangium triangulare.
Coryneum pulicucitum.
Cladosporium herbarum.
Clavaria abietina.
Corticium mearnatum.
Cryptosporium Caricis.
Cystopus candidus.
Dædalea betulina.
Dædalea unicolor.
Depazea cruenta.
Didymium clavus.
Diplodia Buxi.
Dothidea culmicola.
Dothidea gentianæ.
Dothidea Solidaginis.
Dryophilum Perizoideum.
Erineum fagineum.
Erineum luteolum.
Erineum purpureum.
Erineum quercinum.
Erineum roseum.
Erysiphe adunca.
Erysiphe communis.
Erysiphe guttata.
Erysiphe Mors-Uvæ.
Erysiphe myrtellum.
Erysiphe penicillata.
Fistulina hepatica.
Fusarium roseum.
Geaster fimbriatus.
Hydnum aurantiacum.
Hydnum coralloides.
Hysterium Pinastri.
Irpex sinuosus.
Lenzites Cratægi.
Lycoperdon pyriforme.
Macrosporium Cheiranthi.
Nemaspora crocea.
Nectria polythalamia.
Oidium erysiphoides.
Oidium Leucoconium.
Oidium monilioides.
Peziza æruginosa.
Phyllactinia Candollei.
Pileolaria brevipes.
Polyporus cinnabarinus.
Polyporus merandianus.
Polyporus mucidus.
Polyporus squamosus.
Polyporus betulinus.
Polyporus sulphureus.
Polyporus versicolor.
Polyporus zonatus.
Polythrincium Trifolii.
Puccinia aculeata.
Puccinia Amorphæ.
Puccinia asteris.
Puccinia Circææ.
Puccinia compositarum.
Puccinia Graminis.
Puccinia hyssopi.
Puccinia Menthæ.
Puccinia Polygonorum.
Puccinia Saniculæ.
Puccinia Saxifragarum.
Puccinia striola.
Puccinia Vaginalium.
Puccinia Violæ.
Puccinia Xanthii.
Rhytisma Andromedæ.
Rhytisma punctatum.

Schizophyllum commune.	Triphragmium clavellosum.
Sclerotium clavus.	Uredo agrimonix.
Sphæria Andromidarum.	Uredo apiculoso.
Sphæria argillacea.	Uredo Arcææ.
Sphæria Coryli.	Uredo Asterum.
Sphæria fragiformis.	Uredo candida.
Sphæria Graminis.	Uredo capræarum.
Sphæria marginata.	Uredo caryophyllaceænum.
Sphæria picea.	Uredo cylindinia.
Sphæria polymorpha.	Uredo effusa.
Sphæria punctiformis.	Uredo epilobii.
Sphæria Trifolii.	Uredo epitea.
Sphæria ulmea.	Uredo Filicum.
Sphæria verrucosa.	Uredo labiatarum.
Sphæria Yuccæ.	Uredo mixta.
Sphæronema consors.	Uredo ovata.
Spilocœa Pomi.	Uredo petroselini.
Stemonitis fusca.	Uredo polygonorum.
Stereum fasciatum.	Uredo pyrolæ.
Stereum hirsutum.	Uredo Rosæ.
Thelephora caryophyllæa.	Uredo Rubigo.
Trichoderma viride.	Uredo ruborum.
Trichothecium roseum.	Uredo Solidaginis.
Tubercularia minor.	Uredo Toxicodendrii.
Tubercularia vulgaris.	Uredo vitellinæ.

ALLIANCE II. MYCETALES, Berkeley. B *Lichenales*, Berkeley.

Whatever value attaches to this very complete list of lichens is due to the care and industry of Mr. A. T. Drummond of Ottawa, C. W., whose determinations have all been verified by Prof. Tuckerman. The collections of Mr. Billings, Mr. Macoun, and of the Editor, have confirmed Mr. D.'s observations, but have added very little to them. The nomenclature is that of Tuckerman's Synopsis, such species as are not therein described have the authority added.

Arthonia spectabilis, Flot.	Calicium subtile.
Bæomyces roseus.	Calicium trachelinum.
Biatoria aurantiaca.	Calicium turbinatum.
Biatoria Byssoides.	Cetraria aurescens.
Biatoria icmadophila.	Cetraria ciliaris.
Biatoria decolorans, var. lignicola.	Cetraria glauca.
Biatoria ocrop hæa.	β sterilis.
Biatoria rufo-nigra.	Cetraria Islandica.
Biatoria Schweintzii, Fr.	γ crispa.
Biatoria suffusa, Fr.	Cetraria lacunosa.
Biatoria vernalis.	α Atlantica.
Calicium lenticulare.	Cetraria nivalis.
Calicium phæocephalum.	Cetraria Oakesiana.

- Cetraria pinastri.*
Cladonia amaurocræa.
Cladonia cornucopioides.
Cladonia cornuta.
Cladonia cristatella, Tuck.
Cladonia deformis.
Cladonia degenerans.
Cladonia digitata.
Cladonia fimbriata.
 α junior.
Cladonia Floerkiana.
Cladonia furcata.
 δ subulata.
Cladonia gracilis.
 α verticillata.
 β cervicornis.
 γ hybrida.
Cladonia macilenta.
Cladonia parasitica.
Cladonia pyxidata.
Cladonia rangiferina.
 β sylvatica.
 γ alpestris.
Cladonia squamosa.
Cladonia turgida.
 var. *grypa*, Tuck.
Cladonia uncialis.
 γ turgescens.
 α adunca.
Collema nigrescens.
Collema saturninum.
Collema—N. sp., Tuck. MSS.
Conotrema urceolatum.
Endocarpon miniatum.
 β complicatum.
Endocarpon manitense, Tuck.
Evernia furfuracea.
Evernia jubata.
 β chalybeiformis.
 δ setacea.
 γ implexa.
Evernia ochroleuca.
Evernia prunastri.
Lecidea albo-cærulescens.
Lecidea atro-alba.
Lecidea contigua.
Lecidea enteroleuca.
Lecidea geographica.
Lecidea melancheima.
Lecidea parasema.
Lecidea petræa, Tuck.
Lecidea premnea.
Lecidea rubella, Tuck.
Lecidea sabuletorum.
Leptogium lacerum.
Leptogium tremelloides.
Nephroma arcticum.
Nephroma Helveticum.
Nephroma resupinatum.
Opegrapha atra.
Opegrapha inusta.
Opegrapha scripta.
 β recta.
 γ serpentina.
Opegrapha varia.
Parmelia albella.
Parmelia aleurites.
Parmelia badia.
Parmelia Borreri.
 β rudecta.
Parmelia calcarea.
Parmelia caperata.
Parmelia centrifuga.
Parmelia cerina.
Parmelia chrysouleuca.
Parmelia chrysophthalma.
Parmelia ciliaris.
Parmelia cinerea.
Parmelia colpodes.
Parmelia conspersa.
Parmelia crinita.
Parmelia detonsa.
Parmelia elegans.
Parmelia hypoleuca.
Parmelia lanuginosa.
Parmelia lævigata.
Parmelia maritima ?
Parmelia microphylla.
Parmelia obscura.
 β ulothrix.
 var. *ciliata.*
Parmelia olivacea.
Parmelia oreina.
Parmelia pallescens.

<i>Parmelia pallescens</i> , β Parella.	<i>Pertusaria faginea</i> .
<i>Parmelia parietina</i> .	<i>Ramalina calicaris</i> .
<i>var. stellata</i> , Nyl.	β <i>fastigiata</i> .
γ <i>rutilans</i> .	δ <i>farinacea</i> .
δ <i>laciniosa</i> .	α <i>fraxinia</i> .
ε <i>polycarpa</i> .	γ <i>canaliculata</i> .
<i>Parmelia perforata</i>	<i>Solorina saccata</i> .
<i>Parmelia perlata</i> .	<i>Sphærophoron compressum</i> .
β <i>olivetorum</i> .	<i>Sphærophoron coralloides</i> ?
<i>Parmelia physodes</i> .	<i>Stereocaulon denudatum</i> .
β <i>enteromorpha</i> .	<i>Stereocaulon paschale</i> .
<i>Parmelia pulverulenta</i> .	<i>Stereocaulon tomentosum</i> .
<i>Parmelia rubiginosa</i> .	<i>Sticta crocata</i> .
<i>Parmelia saxatilis</i> .	<i>Sticta glomerulifera</i> .
<i>Parmelia saxicola</i> .	<i>Sticta linita</i> , Ach.
<i>Parmelia scruposa</i> .	<i>Sticta pulmonaria</i> .
<i>Parmelia sophodes</i> .	<i>Sticta scrobiculata</i> .
<i>Parmelia sorediata</i> .	<i>Umbilicaria Dillenii</i> .
<i>Parmelia speciosa</i> .	<i>Umbilicaria hirsuta</i> .
<i>Parmelia stellaris</i> .	<i>Umbilicaria Muhlenbergii</i> .
α <i>stellari-expansa</i> .	<i>Umbilicaria Pennsylvanica</i> .
β <i>hispidia</i> .	<i>Umbilicaria polyphylla</i> .
γ <i>tribracia</i> .	β <i>deusta</i> .
<i>Parmelia subfusca</i> .	<i>Umbilicaria pustulata</i> .
β <i>distans</i> .	β <i>papulosa</i> .
<i>var. crenulata</i> , Schaer.	<i>Usnea angulata</i> .
<i>Parmelia tartarea</i> , β <i>frigida</i> .	<i>Usnea barbata</i> .
<i>Parmelia terebrata</i> .	α <i>florida</i> .
<i>Parmelia tiliacea</i> .	β <i>strigosa</i> .
<i>Parmelia triptophylla</i> .	δ <i>hirta</i> .
<i>Parmelia varia</i> .	ζ <i>dasypoga</i> .
γ <i>sepincola</i> .	<i>var. pendula</i> .
β <i>aitema</i> ?	<i>Usnea cavernosa</i> , Tuck.
<i>Parmelia vitellina</i> .	<i>Usnea longissima</i> .
<i>Peltigera aphthosa</i> .	<i>Usnea trichodea</i> .
<i>Peltigera canina</i> .	<i>Verrucaria alba</i> .
<i>Peltigera horizontalis</i> .	<i>Verrucaria Drummondii</i> , Tuck.
<i>Peltigera polydactyla</i> .	<i>Verrucaria epidermis</i> .
<i>Peltigera rufescens</i> .	<i>Verrucaria nigrescens</i> .
<i>Peltigera venosa</i> .	<i>Verrucaria nitida</i> .
<i>Pertusaria pertusa</i> .	<i>Verrucaria rupestris</i> .

ALLIANCE III. CHARACEALES, Berkeley.

Chara vulgaris, Linn.

Chara flexilis, Linn.

And several other forms not yet determined.

ALLIANCE IV. MUSCALES, Berkeley.

In addition to the lists which have already appeared in the *Naturalist*, the Editor is under obligations to Mr. Barnston, Mr. Drummond, Mr. B. Billings, and Mr. Macoun for very complete lists of the collections made by them. Mr. Drummond's list included the collections of Mr. John Bell. Mr. Macoun's Liverworts were determined by Mr. C. F. Austin, of New York, and his more obscure Mosses by Mr. Sullivan, whose nomenclature has been followed, (*Vide* Gray's Manual, Ed. 2,) such plants as are not there described having the authority attached.

HEPATICÆ, Linn.

Aneura palmata.
Calypogeia trichomanis.
Fegatella conica.
Fimbriaria tenella.
Frullania æolitis.
Frullania Eboracensis.
Frullania Grayana.
Frullania saxatilis.
Frullania Tamarisci.
Frullania Virginica.
Geocalyx graveolens.
Jungermannia albicans.
Jungermannia barbata.
Jungermannia bicuspidata.
Jungermannia connivens.
Jungermannia curvifolia.
Jungermannia divaricata.
Jungermannia exsecta.
Jungermannia excisa, Dicks.
Jungermannia Francisci, Hook.
Jungermannia Michauxii.
Jungermannia minuta, Crantz.
Jungermannia Schraderi.
Jungermannia setacea.
Jungermannia Taylori.
Jungermannia trychophylla.
Jungermannia ventricosa.
Lejeunia supyllifolia.
Lepidozia reptans.
Lophocolea bidentata.
Lophocolea heterophylla.
Madotheca platyphylla.
Madotheca porella.
Marchantia polymorpha.
Mastigobryum trilobatum.
Plagiochila asplenoides.

Plagiochila porelloides.
Preissia commutata.
Ptilidium ciliare.
Radula complanata.
Reboulia hemisphærica.
Riccia fluitans.
Riccia lutescens.
Riccia natans.
Scapania undulata.
Sphagnæcetes communis.
Steetzia Lyellii.
Trichocolea Tomentella.

MUSCI, Jussieu.

Anomodon apiculatus.
Anomodon attenuatus.
Anomodon obtusifolius.
Anomodon viticulosus.
Atrichum angustatum.
Atrichum undulatum.
Aulacomnion heterostichum.
Aulacomnion palustre.
Barbula convoluta.
Barbula mucronifolia.
Barbula ruralis.
Barbula tortuosa.
Barbula unguiculata.
Bartramia fontana.
Bartramia Marchica.
Bartramia Cederi.
Bartramia pomiformis.
Bryum argenteum.
Bryum bimum.
Bryum cæspiticium.
Bryum capillare.
Bryum crudum.
Bryum Duvalii.

- Bryum inclinatum*, Bry. Eur.
Bryum pallescens.
Bryum nutans.
Bryum pseudo-triquetrum.
Bryum pyriforme.
Bryum roseum.
Bryum turbinatum.
Bryum Wahlenbergii.
Buxbaumia aphylla.
Ceratodon purpureus.
Climacium Americanum.
Climacium dendroides.
Cryphæa glomerata.
Cylindrothecium cladorrhizans.
Cylindrothecium seductrix.
Dichelyma capillaceum.
Dichelyma pallescens.
Dicranum congestum.
Dicranum Drummondii.
Dicranum elongatum.
Dicranum flagellare.
Dicranum fulvum, Lind.
Dicranum heteromallum.
Dicranum interruptum.
Dicranum longifolium.
Dicranum montanum.
Dicranum polycarpum.
Dicranum Schraderi.
Dicranum scoparium.
Dicranum Scottianum, Turn.
Dicranum undulatum.
Dicranum varium.
Dicranum virens.
Didymodon luridus.
Didymodon rubellus.
Diphyscium foliosum.
Distichium capillaceum.
Distichium inclinatum.
Drummondia clavellata.
Encalypta ciliata.
Encalypta rhabdocarpa.
Fissidens adiantoides.
Fissidens bryoides.
Fissidens grandifrons.
Fissidens osmundioides.
Fissidens hypnoides.
Fontinalis antipyretica.
Fontinalis biformis.
Fontinalis Frostii, Sulliv.
Funaria hygrometrica.
Grimmia trichophylla, Grev.
Gymnostomum curvirostrum.
Hedwigia ciliata.
Homalothecium subcapillatum.
Hypnum abietinum.
Hypnum acuminatum.
Hypnum adnatum.
Hypnum aduncum.
Hypnum albulum.
Hypnum Alleghaniense.
Hypnum Blandovii, W. et M.
Hypnum confervoides, Schw.
Hypnum cordifolium.
Hypnum Crista-castrensis.
Hypnum cupressiforme.
Hypnum curvifolium.
Hypnum cuspidatum.
Hypnum delicatulum.
Hypnum denticulatum.
Hypnum deplanatum.
Hypnum elegans.
Hypnum eugyrium.
Hypnum fluitans.
Hypnum giganticum, Schimp.
Hypnum gracile.
Hypnum Haldanianum.
Hypnum hians.
Hypnum imponens.
Hypnum lætum.
Hypnum minutulum.
Hypnum molluscum.
Hypnum nitens.
Hypnum orthocladon.
Hypnum paludosum.
Hypnum polygamum.
Hypnum polymorphum.
Hypnum pulchillum, Dicks.
Hypnum radicale.
Hypnum recurvans.
Hypnum reptile.
Hypnum revolvens.

- Hypnum riparium.*
Hypnum rusciforme.
Hypnum rutabulum.
Hypnum salebrosum.
Hypnum Schreberi.
Hypnum scitum.
Hypnum scorpioides.
Hypnum serpens.
Hypnum serrulatum.
Hypnum splendens.
Hypnum squarrosus.
Hypnum Starkii.
Hypnum straminium.
Hypnum strigosum.
Hypnum subtile.
Hypnum sylvaticum.
Hypnum tamariscinum.
Hypnum triquetrum.
Hypnum trifarium.
Hypnum umbratum.
Hypnum uncinatum.
Hypnum velutinum, Linn.
Leptodon trachomitrium.
Leskea obscura.
Leskea polycarpa.
Leskea rostrata.
Leucobryum glaucum.
Leucobryum minus.
Leucodon julaceus.
Meesia longiseta.
Meesia uliginosa.
Mnium affine.
Mnium cuspidatum.
Mnium Drummondii.
Mnium hornum.
Mnium orthorhynchum.
Mnium punctatum.
Mnium rostratum.
Mnium serratum.
Mnium spinulosum.
Mnium stellare.
Myurella apiculata, Bry. Eur.
Neckera Macounii, Sulliv.
Neckera pennata.
Omalia trichomanoides.
Orthotrichum affine.
Orthotrichum anomalum.
Orthotrichum Canadense.
Orthotrichum crispulum.
Orthotrichum crispum.
Orthotrichum cupulatum.
Orthotrichum Hutchinsiae.
Orthotrichum leiocarpum.
Orthotrichum Ludwigii.
Orthotrichum Rogeri.
Orthotrichum speciosum.
Orthotrichum strangulatum.
Phascum cuspidatum.
Phascum Sullivantii.
Physcomitrum pyriforme.
Platygyrium repens.
Pogonatum alpinum.
Pogonatum capillare.
Polytrichum commune.
Polytrichum formosum.
Polytrichum gracile.
Polytrichum juniperinum.
Polytrichum piliferum.
Pylaisæa intricata.
Pylaisæa polyantha, Bry. Eur.
Racomitrium canescens.
Racomitrium fasciculare.
Racomitrium microcarpon.
Racomitrium Sudeticum.
Schistidium apocarpum.
Sphagnum acutifolium.
Sphagnum contortum.
Sphagnum cuspidatum.
Sphagnum cyclophyllum.
Sphagnum cymbifolium.
Sphagnum fimbriatum.
Sphagnum squarrosus.
Tetraphis pellucida.
Tetraplodon angustatus.
Thelia hirtella.
Timmia megapolitana.
Trematodon ambiguus, Bry. Eur.
Trichostomum glaucescens.
Trichostomum pallidum.
Trichostomum rigidulum, Smith.
Trichostomum tortile.
Trichostomum vaginans.
Weisia viridula.
Zygodon Lapponicus.

ALLIANCE V. FILICALES, Berkeley.

The Editor is indebted to Rev. Mr. Brunet, Rev. Prof. Hincks, Dr. Thomas, Mr. Macoun, Mr. Drummond, Judge Logie, Mrs. Traill, and Mr. Barnston, for local fern lists and other information ; he has also availed himself of all the published information within his reach. His personal observations extend through the greater part of Lower Canada as far east as Mingan and Gaspé. The nomenclature is that of Prof. Gray, in the second edition of his Manual of Botany, the varieties being omitted.

EQUISETUM (The Horsetails).

arvense (*Field Horsetail*).

Common everywhere in damp places ; a weed.

eburneum (*Great Horsetail*).

In moist places. Belleville, Mr. Macoun ; Quebec, Abbé Brunet ; probably general.

pratense (*Blunt-topped Horsetail*).

On wet sandy river banks, and elsewhere. General and not uncommon.

sylvaticum (*Wood Horsetail*).

In moist woods, &c. ; general, and not uncommon.

limosum (*Smooth Horsetail*).

Usually in water ; general, and common.

palustre (*Swamp Horsetail*),

In wet places. Lotbinière, Abbé Brunet ; near Toronto, Prof. Hincks ; Belleville, Mr. Macoun ; probably general. This (*E. palustre* of Linn.) is a common European plant ; it is not in Gray's Manual.

robustum (*Stout-stemmed Horsetail*).

In woods and moist places. Dr. Lawson's station, near Toronto, is the only one known to the Editor.

hyemale (*Rough Horsetail*).

In wet places ; general, and common.

variegatum (*Variegated Horsetail*).

In wet sandy places. Abundant along the sandy shores of Lake Ontario, Mr. Macoun ; Anticosti, Abbé Brunet —probably general.

scirpoides (*Smallest Horsetail*).

In moist rocky woods and swamps ; general, and common.

POLYPODIUM (The Polypodies.)

vulgare (*Common Polypody*).

On mossy rocks ; general, and common.

Phegopteris (Mountain Polypody).

In moist woods; general, and common. A variable fern sometimes running into var. (?)

hexagonopterum (Winged Polypody),

which is generally distributed from Montreal westward, but is not common.

Dryopteris (Three-branched Polypody).

In rocky woods; general, and very common.

STRUTHIOPTERIS

Germanica (Ostrich-fern).

In rich moist grounds; general; common near Montreal and westward—apparently less so eastward. [More properly *Onoclea Struthiopteris*].

ALLOSORUS (The Rock-Brakes.)

gracilis (Slender Rock-brake).

In clefts of rocks; general, and not uncommon northwards.

atropurpureus (Purple-stalked Rock-brake).

In the counties of Wentworth, Lincoln, and Welland; rare. As this fern occurs in Vermont near the boundary-line, it is to be sought for in the Eastern Townships.

acrostichoides (Crisped Rock-brake).

On rocky lake-shores; Lake Winnipeg, 1854, Mr. Barnston. (Lake Superior to the Rocky Mountains, according to Prof. D. C. Eaton.)

PTERIS

aquilina (Bracken).

In woods, &c. Generally distributed, and everywhere common; a weed.

ADIANTUM

pedatum (Maiden-hair).

In moist woods; generally distributed from Kamouraska westwards, and usually common. A most graceful fern.

WOODWARDIA

Virginica (Virginian Chain-fern).

In swampy ground. General in Canada West, but not common.

CAMPTOSORUS

rhizophyllus (Walking-leaf).

On shady rocks; somewhat generally distributed from Montreal westwards, but usually rather rare.

SCOLOPENDRIUM

officinatum (*Hound's-tongue*).

On limestone rocks at Owen Sound, C.W., 1857, Rev. Prof. Hincks University College Toronto. Since found in several adjacent localities.

ASPLENIUM (The Spleenworts.)

Trichomanes (*Common Spleenwort*).

On cliffs and rocky banks, general from Quebec westwards, but not common.

viride (*Green Spleenwort*).

In the fissures of moist rocks. General from near Quebec eastwards. (Newfoundland, New Brunswick, and eastern Lower Canada to the Rocky Mountains, and northward to Greenland.) This fern—the *A. viride* of Hudson and all modern botanists,—is common in the Highlands of Scotland, and other alpine localities in Europe. It is not in Gray's Manual.

ebeneum (*Screw-fern*).

Rocky open woods. General (apparently only) in Canada West; rather rare. To be sought for in the Eastern Townships, as it occurs in Vermont and Maine.

angustifolium (*Narrow-leaved Spleenwort*).

In rich woods; general from Montreal westwards, but rather rare.

thelypteroides (*Silvery Spleenwort*).

In moist rich woods. A variable fern; general from Quebec westwards, and sometimes common.

Filix-fœmina (*Lady-fern*).

In moist woods. A very variable fern; generally distributed, and very common.

DICKSONIA

punctilobula (*Gossamer-fern*).

In moist woods; general from near Montreal westwards, and in some localities common.

WOODSIA* (The Hair Ferns).

Ilvensis (*Downy Woodsia*).

On rocks; general; a variable, and often common fern. Very luxuriant near the river Saguenay, with fronds sometimes over a foot long.

* After a somewhat imperfect examination of numerous specimens of our Canadian plants belonging to this genus—imperfect chiefly owing to the limited range of fern literature available in Montreal—I would temporarily re-arrange the species as follows :

alpina (*Blunt-leaved Woodsia*).

Woodsia alpina Newman, Hist. of Br. Ferns, ed. 3, p. 79; Moor, Nature-printed Br. Ferns, pl. cvi; (Not of S. F. Gray, who included *W. Ilvensis* under this name); *Woodsia hyperborea*, R. Br., Hooker's Br. Ferns, t. 7. Being in doubt as to the relation which the plants hitherto placed here, bear to the preceding and succeeding species, I omit further notice of them for the present.

glabella (*Hairless Woodsia*).

In clefts of moist rocks. General from near Quebec eastwards, but scarce.*

CYSTOPTERIS (The Bladder Ferns).

bulbifera (*Common Bladder-fern*).

In moist rocky woods, sometimes in swamps; general, and very common.

fragilis (*Slender Bladder-fern*).

On rocky banks, &c. A very variable fern; general, and common.

ASPIDIUM (The Shield Ferns).

Thelypteris (*Meadow Shield-fern*).

In swamps. A variable fern; general from Quebec westwards, and common.

1. WOODSIA RUFIDULA=*Nephrodium rufidulum* Michx.=*Acrostichum Ilvense* Linn.?=*Woodsia Ilvensis* of Gray's Manual. General throughout Canada and often common.

2. WOODSIA ALPINA=*Acrostichum alpinum* Bolton=*Woodsia hyperborea* Hook., Br. Ferns, t. 7.=*W. alpina* Moor, nat. pr. Br. Ferns, pl. cvi; (not of Newman). May prove not to be specifically distinct from No. 1, though the aspect of the plant is different. Occurs occasionally in eastern Lower Canada, mostly in the neighborhood of waterfalls.

3. WOODSIA HYPERBOREA=*Acrostichum hyperboreum* Liljeblad. Not yet found in Canada.

4. WOODSIA GLABELLA R. Brown, Hook. Fl. Bor. Am. t. ccxxxvii.=*W. alpina* Newman, Br. Ferns, ed. 3, p. 79. Doubtfully distinct from No. 3. General in Lower Canada from near Quebec eastwards.

Mr. Bentham would probably reduce all these to varieties of No. 1. I incline to recognize two species, Nos. 1 and 3; while some Pteridologists would recognise all four.

*I collected this fern in the month of August last near the River Saguenay, and elsewhere in eastern Lower Canada; I have also received from Dr. Thomas specimens collected by him at Rivière-du-Loup. Our Canadian plants are very closely allied to, if specifically distinct from *Woodsia hyperborea* (Liljeblad), as exemplified by a Lapland specimen (legit R. F. Frisshot) in the Herbarium of McGill University.

Nov-Eboracense (New-York Shield-fern).

In wet rocky woods. Range same as last species, but apparently not so common.

spinulosum (Common Shield-fern).

In woods. One of our most variable ferns; generally distributed, and very common.

cristatum (Crested Shield-fern).

In wet woods. As generally distributed, but not so common as the last species. Somewhat variable.

Goldianum (Goldie's Shield-fern).

In rich woods. A stately fern; generally distributed from Montreal westwards, but not common. Slightly variable.

marginale (Marginal Shield-fern).

In rocky woods. General and very common. A variable fern.

fragrans (Sweet-scented Shield-fern).

In clefts of rocks, &c. Kamouraska to Lake Superior and northwards; occurs sparingly as far south as 45° (Rigaud mountain, near Montreal; also Falls of the St. Croix, U. S., *vide* Gray's Manual).*

aculeatum (Prickly Shield-fern).

In rich mountainous woods. Northern shore of Lake Huron (Abbé Brunet) to Kamouraska, eastward and northwards; not common. The North American form is var. *Braunii* of Gray.

acrostichoides (Terminal Shield-fern).

In rocky woods. Varies by having its pinnæ more or less incised. General, and usually common.

Lonchitis (Rough Shield-fern).

On limestone rocks at Owen Sound in 1857; Rev. Prof. Hincks of University College, Toronto. Since found in several adjacent localities. Varies as the preceding species.

* This interesting fern was this year found in some abundance by Dr. Thomas at Rivère-du-Loup, and by myself near the River Saguenay, where it was sometimes very luxuriant, having fronds fifteen inches long; perfectly fruiting fronds from one to two inches long were not uncommon; five to ten inches was the average size. It is the *Polypodium fragrans* of Linn., and is distantly allied to the *Aspidium rigidum* of Europe. It was most probably this fern Prush had in view for his *Aspidium rufidulum*,—his synonym *Nephrodium rufidulum* Michx. (which = *Woodsia ilvensis* (Linn.) of Gray's Manual) being a manifest error.

ONOCLEA

sensibilis (*Sensitive Fern*).

In wet shady places. The sterile fronds extremely variable ;
general and very common.

OSMUNDA (The Flowering Ferns.)

regalis (*Royal Fern*).

In moist woods and swamps ; general and very common.

The American plant differs slightly from the European,
and is known as var. spectabilis.

Claytoniana (*Interrupted Flowering-fern*).

As the last ; equally general and abundant.

cinnamomea (*Cinnamon-fern*).

As the last ; general and common.

BOTRYCHIUM (The Moonworts.)

lunarioides (*Tall Moonwort*).

In dry woods and clearings. A very variable plant ;
generally distributed from Quebec westward, but not
plentiful.

Virginicum (*Rattlesnake-fern*).

In rich woods. A variable plant ; generally distributed
and common.

Lunaria (*Common Moonwort*).

In open woods. A northern plant. General from Hastings
(Mr. John Bell) eastwards, but apparently rare ; being
inconspicuous it may have escaped observation. This
plant—the *B. Lunaria* (Linn.) of Swartz and all modern
authors—is common in many parts of Europe. It is
not in Gray's Manual.

simplex (*Dwarf Moonwort*).

In woods. As the last, of which it may possibly be only a
variety.

OPHIOGLOSSUM

vulgatum (*Adder's-tongue*).

In bogs and wet woods. General and probably not
uncommon. A variable plant.

LYCOPodium (The Club Mosses.)

lucidulum (*Shining Club-moss*).

In cold swampy woods. General, and usually common.

inundatum (*Marsh Club-moss*).

River Mistassini and northward, Michaux, MSS., per Abbé
Brunet ; Hastings, Mr. Macoun ; probably general.

anotinum (*Interrupted Club-moss*).

In woods. A somewhat variable plant ; general, and
common.

LYCOPODIUM

dendroideum (*Ground-Pine*).

In woods; general, and not uncommon.

clavatum (*Common Club-moss*).

In moist woods; general; very common eastward—
apparently less so westward.

complanatum (*Festoon Ground-Pine*).

In woods. A variable plant; very general, and not
uncommon.

SELAGINELLA

selaginoides (*Prickly Club-moss*).

Lake Superior, Agassiz; Swan Lake and northward
Michaux; Anticosti, Abbé Brunet.

rupestris (*Rock Club-moss*).

On dry cliffs. General and sometimes rather common.

apus (*Moss-like Selaginella*).

On moist shady ground. General in Western Canada,
and in some localities plentiful.

ISOETES

lacustris? (*Quillwort*).

Grows profusely on bottom of muddy shallow ponds and
sluggish streams; seemingly general; apparently
rare, but probably overlooked.

EDITOR'S NOTE.—In the foregoing catalogue an attempt has been made to indicate the local distribution of Canadian ferns so far as at present known to me. Some of the species may hereafter prove to have a much wider range than is here accorded to them. Numerous localities are given in detail in the last volume of this Journal,—by Dr. Lawson, at page 262, and by Mr. McCord, at page 354. Descriptions of such as are not in Gray's Manual will be found in Dr. Lawson's article.

I have been unable to authenticate the occurrence of *Polypodium Robertianum* or of *Asplenium marinum* in any part of North America. *Aspidium Filix-mas* and *Asplenium septentrionale* have been found on the Rocky Mountains, and are to be looked for in Canada; *Asplenium Ruta-muraria*, *Lygodium palmatum*, *Botrychum lanceolatum*, *Lycopodium Selago*, *Azolla Caroliniana* and *Marsilea mucronata* are also to be looked for, as they occur close to our southern borders.

D. A. WATT.

Montreal, October, 1865.

THE
CANADIAN NATURALIST.

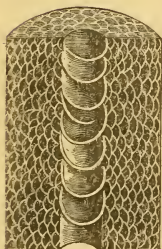
SECOND SERIES.

NOTES ON SOME OF THE MORE REMARKABLE
GENERA OF SILURIAN AND DEVONIAN FOSSILS.

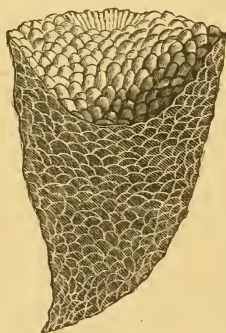
By E. BILLINGS, F.G.S.

(Continued from page 198.)

Genus BEATRICEA, Billings.



2.



3.



1.

1. A specimen of *B. undulata* from the upper part of the Hudson River formation, Rabbit Island, Lake Huron. The original is four feet seven inches in length. 2. Diagram showing the internal structure of *Beatricea*. 3. Section of a *Cystiphyllum*.

The fossils of this genus are elongated sub-cylindrical or club-shaped bodies, from one to twelve inches in diameter and from six

inches to fifteen feet in length. The largest extremity, most probably the base, is pointed or conical, expanding for a few inches, and then, usually, becoming more slender. From this part upwards the body of the fossil either tapers very gradually or remains cylindrical throughout. The upper extremity appears to be abruptly truncated, and to have a central cup, similar to that of the ordinary cyathophylloid corals, but without radiating septa. The surface is either smooth, longitudinally grooved, irregularly corrugated, or covered with small nodular projections. These markings, in most of the specimens, run in nearly straight lines from end to end, but sometimes they have a spiral arrangement, as represented above, in fig. 1. There appears to be also a thin, minutely perforated epidermis.

The internal structure consists of a central tube running the whole length and divided into numerous compartments by concave transverse septa; outside of this a thick layer of vesicular tissue composed of small sub-lenticular or irregularly concavo-convex cells—the convex side of each cell being always turned outwards. This outer vesicular area is usually arranged in a number of concentric layers, of variable thickness, like those of an exogenous tree. Occasionally, specimens are found in which this lamellar structure cannot be detected. The central tube is from one-third of an inch to fifteen lines in diameter; the outer vesicular area from one-fourth of an inch to five or six inches in thickness. There does not seem to be any constant proportion between the two—for specimens of two inches have the central tube as large as it is in those of twelve inches in diameter.

In polished transverse sections, of those individuals which have the surface smooth, the concentric layers of the outer vesicular tissue are seen as so many uniformly circular or ovate rings. But when the surface is corrugated or tuberculated, the rings are undulated, so that the form of the external ridges or tubercles is repeated on each ring, sometimes nearly to the centre.

The true character of the cup, at the smaller extremity, has not yet been ascertained with the certainty that is to be desired. Indeed it seems to be rarely preserved; for although large collections have been made of these fossils, and Mr. Weston, who visited Anticosti last summer, made a special search for this part, only three specimens have been collected which give any clue to its form. One of these is a fragment four inches in length and twenty lines in diameter. When slit in two, longitudinally, by the lapi-

dary's wheel, and polished, the form of the greater part of the cup is well displayed in section. The fossil itself consists of yellowish white calcareous rock, but the cup is filled with grey compact limestone, holding minute fragments of shells, trilobites, and crinoids. The depth of the cavity is thirty lines, and its width at the bottom eight lines. At eighteen lines from the bottom its width is eleven lines, and it then suddenly widens to thirteen lines. Above this the walls are obscurely preserved, although it can be made out that, on one side, they extend at least one inch higher. The central tube is, in this specimen, filled with calcareous spar, and very indistinctly defined. Remains of several of the septa can, however, be seen—their concave side upwards towards the bottom of the cup.

The second specimen is also a fragment, consisting of the upper fourteen inches. The diameter at the lower end, where broken off, is eighteen lines, and at the supposed margin of the cup thirteen lines. Diameter of the central tube about four lines. Depth of the cup, seven and one-fourth inches. The cup is of the same width as the central tube throughout, except in the upper two inches, where it expands to the width of eight lines. The margin of the cup is not well preserved, but as in the last specimen noticed, is broken so that the entire outline cannot be made out clearly. In this specimen it may be that the cup was not more than two or three inches in depth when perfect, and that its apparent extension downwards is due to the destruction of the septa in the central tube below the bottom.

The third example is a large specimen of *B. undulata*, ten feet five inches in length, eight inches in diameter at the base, and six and a-half at the upper extremity. The cup, exposed by a fracture, is nine inches in depth; width at the bottom about nine lines; at four inches above—twenty one lines; then suddenly enlarging to three inches.

In none of these specimens is the margin of the supposed cup perfect. Not the slightest indication of radiating septa can be detected. In order to determine all the characters of this portion of the fossil, specimens with the cup entirely empty and with the margin perfect as it was during the life of the animal, are required. Numerous individuals were seen lying imbedded in the rocks with the larger end well preserved, but in most instances on approaching the smaller extremity, it was found to become more and more obscure, until it at length blended with the matrix. It would thus appear that the

upper end was of a softer and more perishable texture than the lower.

These fossils were first made known to science from specimens collected by Mr. Richardson on the Island of Anticosti in 1856. Occurring in a marine formation, I thought they might be the remains of gigantic sea-weeds, and, in my report for 1857, placed them under the title "PLANTÆ", but next after those that I considered of uncertain class. Since then they have remained in the cases of the museum arranged among the fucoids. In 1858, I took specimens with me to England, and had slices made for microscopic investigation. They were submitted to Dr. Hooker, who at first thought he could detect some traces of plant-structure in them, but on a subsequent examination he came to the conclusion that the evidence was not sufficient to show that they belonged to the vegetable kingdom. Since that time large additional collections have been made, and have been carefully studied by Dr. J. W. Dawson and myself. Dr. Dawson agrees with Dr. Hooker that no plant-structure can be detected, and has long maintained that these fossils constitute a peculiar genus of corals allied to *Cystiphyllum*.* Prof. E. J. Chapman, of Toronto, has also expressed the same opinion.† Prof. J. Hall, and the late S. P. Woodward thought they might belong to the order *Rudistes*. J. W. Salter has made the suggestion that, notwithstanding their great size, they may be annelide tubes.‡ A. Hyatt, jr. excludes them from the vegetable kingdom, and says, that they constitute "a new and interesting order among the Mollusca, closely allied to the Orthoceratites."§

When I first described these fossils I had no specimen that exhibited either of the extremities; the internal structure, with the exception of the central tube and concentric layers, was also unknown. I thought they might be marine plants, but was never perfectly satisfied that they were. The large collections since made have enabled us to ascertain nearly the whole structure.

* This Journal, vol. 3, p. 85.

† "Their true place is probably among the Corals," CHAPMAN,—Canadian Journal, New Series, vol. 3, p. 331.

‡ "Mr. Salter believes that the Beatricea, though thirty feet long, may be a gigantic annelide tube, allied to Cornulites. Its cellular structure leads him to this view. Amphitrite has a thick shelly tube some feet in length.—Sir R. I. MURCHISON,—'Siluria,' ed. 3, p. 460.

§ Am. Jour. Sci. [2] vol. 39, p. 261.

There still remains some doubt as to the cup and epidermis. Granting that the cavity at the small end is natural and not caused by the destruction of the septa in the central tube, then *Beatricea* has all the essential organic parts which constitute a genus of corals allied to *Cystiphyllum*. This may be seen by comparing figs. 2, 3, above. The most remarkable differences are, the great size of the individuals, and the disposition of the cells in the outer layers of vesicular tissue. In *Cystiphyllum* the convex sides of the cells of the walls of the cup are always turned inwards, or sloping upwards and inwards. In *Beatricea* the reverse of this is the case.

As above stated, *Beatricea* was first made known by the specimens collected by J. Richardson, in 1856. It was afterwards, in 1858, found by the same geologist and Prof. R. Bell, at Lake St. John, on the river Saguenay. Mr. Bell has also collected fine specimens on Rabbit and Club Islands, in Lake Huron. There is a specimen in the Museum of the Geological Society of London that was brought from Anticosti, by Admiral Bayfield, many years ago. Mr. Hyatt says that Prof. J. D. Dana has some fragments of a species resembling *B. undulata* from Kentucky. Its geological range, so far as it is at present known, is from the Hudson River formation up to the Clinton.

NOTES ON THE MEETING OF THE BRITISH ASSOCIATION AT BIRMINGHAM, 1865.

In approaching Birmingham from the west, the visitor learns to appreciate the appellation 'black country,' which has long been enjoyed by the Staffordshire coal districts and their neighborhood. The smoke of hundreds of collieries and furnaces and foundries darkens the air; the green fields give place for miles together to piles of coal, cinders and ashes; and in some places the eye can discern, as far as the murky atmosphere will allow it to penetrate, no green thing. In the day, the aspect of the land is dark and lowering; in the night it brightens with the glow of innumerable furnace fires. It is a pity that the green face of nature cannot be preserved where men toil to extract wealth out of the bowels of the earth; but when both ends cannot be secured, the greater number of people can be supported by thus defacing the aspect of nature. The black country is thus, by virtue of its coal and iron, densely populous, greatly thriving, and a chief abode of manu-

facturing industry and wealth. All this centres at Birmingham, where the solid material of iron is made the basis whereon is built a vast variety of workmanship, in all sorts of implements and ornaments.

Birmingham itself is rather at the outskirts of the proper black country, on the red sandstone and conglomerate which overlies the coal field. The environs of the town, in consequence, are in some parts very beautiful, and adorned with numerous seats of the wealthy citizens, whose hospitality was extended most liberally to the members of the British Association. Birmingham is not only a great seat of many interesting manufactures, but is in the very heart of England, and in the midst of a network of railways so complicated as almost to puzzle the stranger desirous of visiting it. It has besides some excellent public edifices, well adapted to the meetings of a scientific parliament, more especially its new Town Hall, and the buildings of the Midland Institute and of King Edward's School. Hence the British Association has thrice met at Birmingham, and the success of its last meeting may well induce it to meet there again, should it have opportunity.

The British Association has now attained the mature age of thirty-five years. Its initial meeting at York assembled mainly through the instrumentality of Prof. Phillips; and this eminent geologist, who also presided at the Birmingham meeting, has, as Secretary of the Association, been its most active promoter during its whole existence. At a luncheon given to the members by the Mayor of Birmingham, Sir Roderick Murchison, who calls himself one of the 'Palæozoic members,' thus alluded to its origin:

"In the year 1831, when he was President of the Geological Society of London, his young friend of that day, one John Phillips of York—with whom and his distinguished uncle, the father of English geology, he had previously worked along the coasts of Yorkshire—wrote to him in London, encouraging him to promulgate a proposition which he had, by direction of that most eminent man, William Harcourt, sent up for their consideration. He endeavored to the best of his ability to carry out the wishes of his friend, but what was the result? He could get scarcely anybody to hear of the matter when he first laid it before them, and he could get none to accompany him save his friend Mr. Greenhow, of the Geological Society, and the late Mr. John Taylor. But though London did not respond, Manchester

answered to the call, and sent that most eminent philosopher, Dalton; Ireland sent the Provost of Trinity, Dr. Lloyd; and Scotland was represented by Brewster, and one who had been at that meeting—Professor Forbes, the eminent mathematician. Cambridge was not represented; but from Oxford came Dr. Daubeny, with an invitation to the Association to meet there on the following year. Next year they met under Buckland at Oxford, and they had with them the most eminent scientific men of the day.”

Since that time the Association has grown to be one of the great institutions of England. Peripatetic and without local habitation, essentially free and easy in its management, loose in its regulations, and democratic in its character, it is the most popular of British scientific societies. Its meetings attract thousands of auditors, and its influence, by the wide circulation given to its proceedings through the press, is felt throughout all parts of the British Empire.

The British Association is by no means to be viewed as a scene of scientific dissipation. Nor must its utility be regarded as confined merely to the diffusion of popular information, though this is no small or despicable use. It has important uses to the cultivators of science themselves. It drags them out of their dens, and brings them face to face with each other, and with the world. It gives scope for a free and open interchange of ideas and arguments. It makes those who have attained to high positions, acquainted with the humbler workers in their several spheres. It gives the younger men opportunities of coming forward into notice. It throws those who are the oracles of little coteries at home into the wider competition of the world. It enables scientific men in general better to appreciate the work of each other, and to form more accurate notions of the powers and modes of thought of fellow laborers. It affords excellent opportunities for bringing out new facts and discoveries, under circumstances which give the means of testing their real value, and, if they pass this ordeal, of giving them general currency.

To a student of science, whose ordinary sphere of labor is at a distance from the great centres of scientific work, and who can but rarely have conference with men engaged in similar pursuits with himself, these meetings are particularly valuable, and their value is enhanced by the rarity of opportunities for enjoying them. In our day the aspects of science rapidly change, and the

student who depends for his information regarding them on books and on scientific journals, has, after all, but a faint impression of the newer phases of scientific enquiry. On attending the meeting of the British Association at Birmingham, after a lapse of ten years, I had forcibly presented to my mind many changes in men and things. Some of the older men had passed away, or were disabled by age and infirmities from active labor. Those who were young and little known had attained to maturity of years and an established reputation. A host of younger men had risen up. In those departments of science in which I am more especially interested, many new discoveries had been made, or new theories broached. The striking and prolific doctrine of the correlation of forces had been worked out. The method of spectrum analysis had been devised, enabling us to attain a knowledge of the chemical composition even of distant heavenly bodies. The hypothesis of the indefinite variation of species had been revived, and had rapidly become popular among the younger scientific men. The later tertiary deposits had yielded evidences of the possible existence of man in the time of the extinct mammoth; while the oldest rocks, before esteemed azoic, had yielded evidences of animal life. In physics, in chemistry, in geology, and in natural history, a multitude of new and important facts, filling great volumes of proceedings and transactions, had been discovered and given to the world; so that every department of science might be said to occupy a new stand-point, and a host of new subjects of discussion had arisen. When we think of the vast range of study and investigation comprised in the proceedings of the British Association for the last ten years, and look back to the dim beginnings of science in a distant antiquity, and forward to the possible solutions of the hundreds of questions still agitated, it becomes a matter of doubt whether we should congratulate ourselves on the vast progress made toward the right understanding of nature, or should sink appalled in the presence of the apparent boundlessness of the unknown. True science is ever disposed to view its position with humility, and to regard the ever widening circle of knowledge as only ever enlarging our conceptions of the amount of what remains to be known, before we shall meet that point, where the possibilities of the finite understanding shall be overtaken, in the presence of an incomprehensible infinity.

The sessions of the British Association are limited to a week—a period generally found too short satisfactorily to dispose of the

business. The proceedings open with a public address by the president for the year. The Association then divides into sections, each taking up a special subject, and organising itself with a president, vice-presidents, and committee. The sections at the Birmingham meeting were those of mathematical and physical science; chemical science; geology; zoology, botany and physiology; geography and ethnology; economic science and statistics; and lastly mechanical science. These sections are known respectively by the letters A to G. Each has its own room, and the meetings take place simultaneously, so that persons interested in different subjects are often sorely perplexed by the claims of rival papers; and it is not uncommon, after a popular paper, to see a section-room almost emptied, by the rush to be in time for some other topic of interest, in another section.

The committees of the sections meet every morning to arrange the business for the next day. The section meetings usually extend without intermission from 11 to 3 or 4 in the afternoon, and the evenings are occupied with social entertainments and lectures. It has of late years been the practice to organise excursions to local objects of interest on the Saturday, instead of the close of meetings as formerly, keeping the sections, or some of them, open at the same time. At the Birmingham meeting there were several interesting excursions of this kind; but there was much difference of opinion as to the propriety of having such excursions on a regular day of meeting: some objecting to this, others saying that the sections should adjourn; the result being that those which did not adjourn were very thinly attended. Those who come for scientific purposes would prefer the sections; those who love pleasure, the excursions; and the local authorities do not wish to postpone the excursions to the end, knowing that, in this way, they lose most of the leading men.

The evening entertainments are not merely great crushes of well-dressed people; but they furnish an opportunity for meeting friends, and they are made the occasion of exhibiting many objects of interest in art, in manufactures, and in natural history. One of the evenings at Birmingham was occupied with an interesting lecture by Mr. Jukes, of the Geological Survey, on the probable extent and duration of the coal of South Staffordshire.

In organising the sections, any person, who is a member of a society publishing transactions, may be placed on the committees, and a few leading men are appointed vice-presidents. In some

sections there is a glut of papers, and it is amusing to see the anxiety of some claimants for fame to get their papers in a good place on the list, while the committee is usually desirous to secure for good or popular papers the best places. On the whole, considering the hurried manner in which the work is done, there seems to be much fairness, though many who are disappointed complain of cliques and favoritism.

Prof. Phillips, the president of the year, and one of the founders of the Association, is a man of marked features, florid and light complexion, full eye, and large bald head, with thin whitened hair. His countenance is full of genial kindness and quick intelligence, and his step and manner are almost boyish in their elasticity and vivacity. His first scientific work was done on the Yorkshire coast, and he is now professor of geology at Oxford. He is remarkable for that width of information and accuracy of detail which characterise Dana among the American geologists; and, like him, he is a conscientious man, and a cautious generaliser; always to be found in the right place on moral questions, and never carried off his feet by the rush of novel speculations and hasty conclusions. In such questions as the much controverted glacial theories, he busies himself with accurate experiments and calculations of the crushing weight of columns of ice, and similar essential data; and he has a little astronomical observatory in which he applies, not his hammer, but his telescope to the planets, and has worked out some interesting points in what may be called, for want of a better name, the physical geography of the planet Mars, showing approximately the distribution of its land and water, the movements of its clouds, the advance and recession of its polar snow-patches, and the constitution and temperature of its atmosphere. He is equally at home, and a diligent worker in fossils. Phillips is also a teaching geologist. I spent a most pleasant day with him and his able colleagues, Dr. Acland and Prof. Rolleston, at Oxford, in studying the admirable arrangements in the new museum and scientific library of that university—institutions which are now, thanks to these eminent men and their colleagues, second to none in England, in facilities for the study of physical and natural science. In all that relates to the arrangement of specimens for study, and affording due facilities to the student, Prof. Phillips is as careful and enthusiastic as in his original investigations; and I can imagine no man better suited to cultivate scientific enthusiasm among students, and to send

out from the old university, educated naturalists for the next generation.

In the Geological Section, Sir Roderick Murchison, the president, and Sir Charles Lyell, the first on the list of vice-presidents, were the acknowledged heads; Sedgwick, the only other of the great geological leaders, was absent. Murchison is a man of imposing presence and gentlemanly exterior, bland and affable, ever striving to soften the asperities of discussion. Lyell, a man of less majestic aspect, but with a magnificent head, and thoughtful, penetrating countenance, which, now that age is stealing upon him, impresses one all the more with the fact, that his is the greatest and most logical intellect, that has been brought to bear on the earth's history in our day. Murchison is the geologist of the palæozoic rocks, the most successful systematizer of the older formations, which, before his time, were involved in confusion. Lyell is the geologist of the cainozoic, or more recent period of the earth's geological history, the reducer to order of the heterogeneous and widely scattered tertiary deposits. Murchison, like Phillips, is a conservative geologist, slow to adopt new views, and striving to hold the balance between opposing theories. Lyell is the most progressive, and least conservative of the older geologists, and marches in the van of geological progress with as much alacrity as the youngest votaries of the science.

In glancing from these names to those that follow them in the lists of the Association, I feel that there is a wide interval. The present state of natural science in England is that of a rapid transition from an era of giants to an era of mediocre men. This has often been the case in the history of science. One generation produces a crop of great men: the next, perhaps, a multitude of useful, but not brilliant or distinguished followers. It is quite apparent that such men as Lyell, Murchison, Sedgwick, Phillips, Owen, and Faraday have no worthy successors in their special departments of science in England. Not that able, hard-working, and successful men are wanting. There are many such; but it is evident that when the older men die off, their places will be occupied by far inferior minds; many of them mere collectors of facts, others framers of hypotheses which carry them away from truth; the best only fitted to carry forward creditably the work which men of greater genius have originated.

One of the most interesting subjects of geological enquiry at present is the question of the antiquity of man; or, more properly,

the question, with which of the later tertiary animals were the first men contemporary? In so far as Western Europe is concerned, there seems to be evidence that several great mammals have become extinct since man appeared on the stage, as, for example, the megaceros, or great Irish stag, the cave bear, and, perhaps, the mammoth and tichorhine rhinoceros. I believe, however, after a careful study of the accounts given of the several deposits in caves and elsewhere, in which these evidences are found, and after personal examination of the celebrated gravel-pits near Amiens, that any inference as to the absolute antiquity of man is altogether premature; and, indeed, the question as to which of the extinct quadrupeds of the later tertiary were contemporaneous with man, is far from being settled. One of the most interesting documents, relating to this subject, presented to the Association, was the report by Mr. Pengelly on the exploration of the cave near Torquay, called Kent's Hole, for which exploration a grant had been given by the Association. This cave presents on its floor four layers of different antiquity. 1. Blocks of stone fallen from the roof; 2. Black loam; 3. Stalagmite or calcareous matter, formed by the dripping of water, and mixed with stones; 4. Red clay or loam. In the upper layers are found modern objects—from the porter bottles thrown away by pleasure parties, to old bronze implements perhaps 2000 years old. In the stalagmite and clay are found a few stone implements, and the bones of animals, many of them now extinct. Much yet remains to be done in this cave, but it seems to have been proved that the flint weapons must be as old as the time when the extinct cave bear lived in England. The mode of exploration pursued is very careful. The interior of the cave is divided into sections, and in each of these the loam is carefully removed, and the objects found in each layer and in each section of the layer are placed in separate labelled boxes, so that every specimen can be referred to the exact spot and depth from which it is obtained. In this way it is hoped that a series of indisputable facts relating to the animals which may have been contemporary with the primitive men of the stone age in England, may be obtained.

Another subject of discussion, belonging to the later tertiary period, is the agency of glaciers and icebergs in distributing the materials of the post-pliocene drift, and in excavating the basins of lakes. Prof. Ramsay, the great advocate of the theory of continental glaciers, was, unfortunately, absent; and most of the

leading geologists present, being content with the received ideas of the joint action of icebergs and glaciers, there was little discussion, although several valuable papers were read, the most important being that of Prof. Phillips, on the physical conditions of the existence of glaciers.

Passing from the newest geological formation to the oldest, a very important communication, by Mr. Salter and Mr. Hincks, detailed the discovery of many curious fossils in rocks of the Cambrian period, below the oldest fossils hitherto known in England. They curiously illustrate the fact that, in the beginning of the animal life of the palæozoic period, all of the three lower provinces of the animal kingdom were represented; a striking contrast in this respect to the still older Laurentian, with its one fossil—the *Eozöon*—a representative of one, and that the most humble of the types of animal life. Mr. Salter also applied his discovery, in a very happy manner, to the illustration of the parallelism between the oldest silurian rocks of America and Europe; and more especially to the connection of the gold producing rocks, with the old slates holding *Paradoxides*, one of those curious connections between fossils and useful minerals which are constantly occurring, and which show the practical value of the study of fossil remains.

A paper by Prof. Harkness, on the limestones of Connemara, supposed to contain fossils similar to the *Eozöon* of the Canadian Laurentian, gave an opportunity of explaining to the section the steps by which the discovery of the fossil and its determination had been reached in this country. Prof. Harkness maintained, in regard to the Connemara rocks, that they are really Lower Silurian, not Laurentian, and that they contain no true Foraminiferal remains, but the Canadian discovery was accepted on all hands as undoubted.

The writer happened to be the only representative of Canadian geology at the meeting, and, in that capacity, was honored by appointment as one of the vice-presidents of the section. He presented two communications, one on the succession of fossil plants in the older geological formations as evidenced in America; the other on the conditions of deposit of our boulder clay, and the evidence as to the climate of the period afforded by fossil plants. Both were well received, and led to some discussion; and he can testify, on this as on previous occasions, of the scientific men of Britain, that they are ever ready to receive a colonial brother on equal terms with themselves, and show none of that mean contempt for colonists which is too conspicuous in the political press of Eng-

land. Scientific bodies, like the British Association and the learned societies of England, do not treat colonists as foreign members. They assign to them the same rights and duties as if they resided in the British Islands, evidencing in this way a truly imperial spirit in regard to the dependencies of the British Crown ;—a spirit which would repudiate the Greek or Chinese policy of keeping colonies at a distance until they become strong enough to give trouble, and then casting them off, and would adopt instead the Roman principle of universal citizenship of the empire, extending over all its dependencies throughout the world.

This digression leads me to glance next at the Section of Geography and Ethnology, under the presidency of Sir Henry Rawlinson, the decipherer of the Nineveh inscriptions, and a courteous and amiable man. This is one of the most popular of the sections. Its stirring narratives of foreign travel in the central deserts of Asia, and in unexplored regions of Africa, attract all hearers ; and the presence of the men actually engaged in these adventurous expeditions, increases the attraction. At the late meeting there were interesting communications as to the discovery, by Mr. Baker, of additional sources of the Nile, beside those made known by Speke, an exhibition of large paintings of the remarkable Victoria Falls on the Zambesi, and interesting discussions as to the proposed Palestine exploring expedition, and the expediency of another expedition with the view of reaching the North Pole.

A curious and somewhat disturbing element in this section is the presence of the anthropologists, as they call themselves, a small but active body of scientific men, who have established a society in London with the view of studying the natural history of man. The object is, no doubt, good ; but, unfortunately, it necessarily becomes mixed up with discussions about the unity of the human race, the probable descent of men from apes, and many other questionable subjects, which repel prudent and conscientious men, and are attractive to people who are eminent in nothing but in differing from other sensible persons. But the anthropologists are ambitious. They publish a journal, and they desiderate a separate section of the British Association. This was declined at the opening meeting of this year, but a compromise was entered into, and the greater part of the papers were handed over to the Geographical Section, coming under the head of ethnology. A very elaborate paper of this class was one by Mr. Crawford on the

African Negroes, in which, while he adduced a vast variety of considerations tending to show their inferiority to other races of men, he nevertheless maintained that it was idle to imagine that they formed a link between men and monkeys. The writer seemed to have hit that exact mean which offends all parties. The more advanced anthropologists were indignant that he had not followed out his facts to the conclusion that the negro is only a better kind of ape. Others were disposed to repudiate as unfounded the alleged inferiority of the negro altogether. One of the points referred to in the paper, was the odor of the negro. To this a clever answer was given by a gentleman from the United States who happened to be present. He said that—“He could say, from actual knowledge and experience in the South, that the offensive smell of the negro was not regarded there. The whites were perfectly willing to associate with them on very intimate terms. No Virginian lady drove out without her negro maid in the carriage with her, and they slept in the same rooms with the young ladies, in the most aristocratic families. The only objection he had heard to the negroes as to their offensiveness, was when they were offensive enough to be free. The fact was, they were only offensive when they were overworked and unwashed, and persons of that class were, to a certain extent, to be found in every country.”

Another objection to the negro was that he had not invented an alphabet; but it was urged in reply that the same might be affirmed of the English race—an argument not unlike that adduced by a learned African at the Newcastle meeting of the Association, when he alleged, that the Romans had held that British captives were too stupid to be used as slaves, and since the negroes were already somewhat advanced above that level, good hopes might be entertained of them. In truth, the attempt to establish different species of men has been so completely overthrown by scientific reasoning, and is so abhorrent to right feeling and to revelation, that it is now scarcely tolerated by any intelligent audience in England.

In the Section of Zoology and Botany, presided over by Dr. Thomson, and the so-called Sub-section of Physiology, under the presidency of Dr. Acland, many interesting papers were read. One of the most popular, to judge by the notices of it in the newspapers, was a lengthy exposition of the methods and results of oyster culture, by Frank Buckland. The young oyster is

locomotive when first detached from the parent, and in this state the 'spat,' as it is called, must attach itself to some fixed objects called 'cutch' before it can be developed into the perfect native, fit for educated human palates. Shells of dead oysters seem to be the favorite 'cutch,' but mussel shells and shells of other mollusks, and even pieces of earthenware and tiles, are not objected to. The importance of dead oyster shells, to afford holding ground to the new brood, was thus illustrated:

"There are but few localities where the shells of the dead oysters have accumulated in sufficient quantity to give the spat a chance of adhering. It is, therefore, necessary to collect these shells from elsewhere, and throw them down upon localities where the spat is likely to fall. This process is carried out by oyster culturists on a pretty large scale, and it seems almost providential that beds of oyster shells should be found in the neighborhood of the grounds which are cultivated. Thus, for instance, you will see on the map, a place called 'Pan Sand,' at the mouth of the Thames. Now, at this spot there is an accumulation of oyster shells, and dredging boats from various localities dredge up these shells, and carry them on to places nearer in shore and throw them again to the bottom of the sea, knowing full well that if there be spat floating about, and if they be in a proper condition to adhere, that this cutch will assuredly catch it. How this Pan Sand oyster bed came into existence I am quite unable to tell you; but from the appearance of the oysters themselves, I can assert that the oysters were of great age, that they had lived there many years undisturbed by dredgers, and that a considerable time has elapsed since they thrived in this locality."

The oyster culture is now a very important branch of business, and I see that one sanguine theorist proposes to stock the whole estuary of the Thames with live oysters, to feed them on the sewage of London, and then, in turn, feed the whole population of London on the oysters.

The separation of physiology, or, as some prefer to call it, biology, from technical zoology and botany, is an indication of a somewhat important fact, namely, that those naturalists who have devoted themselves to questions of comparative anatomy, of chemical physiology, and researches as to the nature of vital force and the origin of species, regard questions of zoological and botanical classification and of geographical distribution with impatience, and are disposed more and more to separate themselves from the

ordinary working naturalist. The effect of this, along with the almost inevitable tendency of specialists to underrate other branches of study than their own, will, without doubt, be in some respects damaging to the true progress of science; and, for some time, we must be prepared to find much good work spoiled by defective and one-sided classification, and crude hypotheses about the production of species by natural selection, and the supposed identity of vital forces with the forces of inorganic nature. The scientific pendulum swings just now in this direction; and it is not unusual to find men framing new classifications on the most petty anatomical grounds, without regard to broader affinities, reasoning about the convertibility of species in precisely the same strain in which alchemists, centuries ago, descanted about the transmutation of the metals, and imagining that because vital force supports itself at the expense of heat, or light, or electricity, that therefore it is identical with them: but the pendulum will swing back, and we shall find, perhaps, that the machine has, after all, kept up with the time; though it is sad to think that the path of knowledge is so tortuous, that so few can reach the goal, and that the oscillations of the pendulum represent so much vain expenditure of highly endowed mind.

It must, however, be admitted that much of the present difficulty in the way of sound biological science arises from the vast extent of the ramifications of the subject, and the impossibility of its being all grasped by one mind. In this way the very enlargement of our knowledge becomes a source of weakness, and the great empires of the earlier zoologists become broken up with petty and powerless principalities. Only those great minds which appear at very rare intervals can rescue natural science from this kind of disintegration; and perhaps the time may come when no possible mind can do this. The question is not yet solved whether the power of generalization can keep pace with the collection of facts in nature. At present, of English-speaking naturalists we have only Agassiz and Owen who are at all able to grapple with the greater and wider questions of zoology, and both of these men are borne down with an intolerable amount of labor. Dr. Acland thus discoursed in his opening address on the difficulties of the subject:

“Although the wisdom of this Association entitles this meeting a sub-section, I am among the minority who cannot understand the force of the arguments which go to class biology (which

term may be now used synonymously with physiology) as a subordinate subject. Being, when properly considered, the most complicated of all the subject matter debated at this Association, it cannot be really subordinate to any, least of all to zoology and botany, which it distinctly includes. It may be an open question whether physiology be a branch of physics and chemistry; it is not an open question whether it includes the knowledge of the characteristics upon which the classification of all entities that are said to have life is based.

“ For the purposes of the great scientific question of this age, the causes of the present order of life on the globe, it would seem that the minutest accepted data of biological conclusion may have to be revised under new methods. It is a saying among painters, ‘ That a draughtsman sees no more than he knows.’ It is true in the same way in natural science, that the real signification of a known fact may be concealed for ages. Of this, pathology offers many examples. The older naturalists, notwithstanding the great learning of such men as Linnæus and Haller, had comparatively either very simple or hypothetical and incorrect notions of the complexities of living beings and their constituent parts. Chemistry, the microscope, and the search for the origin of species, have, in this century, widened the horizon of biological study in a way not less surprising than does the dawn of day to a traveller, who, having by night ascended some lofty peak, sees gradually unfolding an extent and detail of prospect which he can generally survey, though he cannot hope to verify each detail and visit every nook in the brief time allotted to him to travel.”

One of the ablest workers in these subjects at present, and one whose labors will live, after much that makes more sound now has become obsolete, is Dr. Beale, who read a good paper on “ Life in its connection with cell structures and vital force.”

In the somewhat inverted order in which I have noticed the sections, we come next to those of Mathematical and Physical Science, presided over by Mr. Spottiswoode; of Chemical Science, under the presidency of Prof. Miller, of King’s College, London; and that of Mechanical Science, whose president was Sir William Armstrong of the guns. In the first of these sections a prominent place was occupied by the aeronautic exploits of Mr. Glaisher of the balloon committee, who, instead of slowly and laboriously collecting meteorological facts on the surface of the earth, visits the region of the clouds, and catches the rain and snow in mid-air, making us shiver

with the information that at certain heights above the earth our summer showers are represented by drifts of snow. One of the most interesting facts in the present year's report, is the almost constant occurrence of south-west wind in the higher regions of the air over England—a fact satisfactorily explaining its warm and moist climate. Another most interesting subject, which occupied much of the time of this section, is the observations now being made by many astronomers on the superficial appearance and physical structure of the sun and other bodies of the solar system. Much attention has been given to those vast and remarkable disturbances in the luminous envelope or atmosphere of the sun, known as the solar spots, and it is probable that their laws of occurrence will soon be as well understood as those of the hurricanes and typhoons of our own atmosphere. The exploration of the surface of Mars, by Prof. Phillips and others, I have already referred to; and an elaborate map of the moon is in progress, in which every ridge and ravine of her scarred surface will be represented in such a way as to enable future observers to decide the question whether any physical changes are now in progress in our satellite. Most remarkable results have been obtained by the application of the method of spectrum analysis, and, among others, the interesting fact that the nebula of Orion, which had been resolved into apparent stars, is, after all, a gaseous mass with brighter spots or nuclei of gaseous matter, a fact tending to revive the evidence for the so-called nebular hypothesis of the formation of the solar system. Luminous meteors or shooting-stars were also the subject of a report, in which it was stated that the average height of these bodies is sixty miles above the earth, that the average number in our atmosphere in a day rises to the astonishing amount of seven and a half millions, and that at any one instant there would be found in the space occupied by the earth and its atmosphere 13,000 of such bodies, all of which are supposed, like the greater planetary bodies, to be pursuing orbits of their own. Time would fail even to name the vast number of new facts of industrial importance brought before these sections—the Atlantic telegraph—the improvements in gun cotton—the applications of photography—researches in organic chemistry—new methods of coating iron with copper—machinery for extraction of coal—Bessemer's process for making steel—and the improvements in furnaces, are only a few of these subjects; and, with regard to one of these, it was stated by Sir W. Armstrong that it is not uncommon in ordinary

furnaces to have two-thirds of the heat produced absolutely lost, while it would seem that in steam-engines no less than nine-tenths of the force generated is wasted.

In connection with this, and with a matter of interest to this country, where peat is already being worked, it was stated that a material named Torbite, suitable for the purposes to which coal is applied, may be made from peat, and sold at from 10s. to 12s. per ton, and that there are in Great Britain and Ireland no less than five millions of acres of peat, with an average depth of twenty feet.

The Section of Statistics was presided over by Lord Stanley, a man of unprepossessing appearance, with a somewhat nervous manner, but a close thinker and able speaker, markedly distinguished by a certain dogmatic utterance of plain common sense. In his opening address, he thus vindicated the claim of statistics to a place in the work of the Association :

“ It has been questioned how far such subjects ought to form part of the business of a strictly scientific association ; and I do not think the question unreasonable, for it must be admitted that, while our political economy itself, in its present state, is rather a collection of practical maxims, supported by reasoning, and tested by experience, than a science, in the same sense that astronomy or optics is entitled to that name, the topics to which the statistical method is applicable are infinitely various, and have little in common except this one characteristic—that in every case we appeal either to the numerical test of accuracy in figures, or else to fixed and recognised rules, which are assumed to have the same kind of certainty as prevails in physical science. How far that assumption holds good in practice must depend on the judgment both of those who read papers, and of those who comment upon them. The truth is, in my opinion, that our functions here are rather those of suggesting and stimulating than of originating thought. Discussion, no doubt, we shall have, and in discussion new ideas are constantly generated, and new lights thrown upon previously unfamiliar topics ; but it is not in crowded meetings, it is not in debating speeches, that any profound and original investigation can be carried on. Meetings like ours answer two purposes, apart from that of social enjoyment ; one is the diffusion—not the origination, but the diffusion—of ideas. Books and newspapers and reviews, no doubt, are the main agents for doing that work. Still it is, I think, indisputable that as seeing is proverbially

more impressive than hearing, so what we hear orally delivered makes upon us a stronger impression than that which lies on a printed page on which our attention may or may not dwell. The other is the stimulus given to enquiry by the mere fact of investigations of this kind, or the result of them, being brought prominently or conspicuously before the public. Men go home with their heads full of subjects on which they perhaps never thought seriously before; and since, as I believe, nothing once known is ever really forgotten, since an idea which has once found lodgment in the mind, though its presence there may long have been barren, and though we ourselves may have been unconscious of it, will often spring up into life, after a long interval, it is difficult to determine what crop will not grow, sooner or later, out of the seed thus cast about apparently at random."

The following counsels to the readers of papers and speakers in the discussions, might be advantageously given to other bodies as well, and with them I shall close these notes;

"Let me only offer to those who take part in our discussions one or two suggestions. The first is, time runs fast. You can say all you have got to say in a few words, if you will think it over beforehand. It is want of preparation, want of exact thought, that makes diffuseness. Again: we don't want preambles or perorations. We are not a school of rhetoric; and in addressing an educated audience a good deal may be taken for granted. Lastly, we only wish to get at the truth of things. All ideas are welcome, but mere verbal criticism is of no value to us." J. W. D.

NOTICE OF SOME NEW GENERA AND SPECIES OF PALÆOZOIC FOSSILS.

By E. BILLINGS, F.G.S.

Genus CALAPOECIA, (N. G.)

Corallum composite, forming hemispherical or sub-spherical colonies. Corallites slender tubular, perforated as in *Favosites* and with their outside striated by imperfectly developed costæ. Radiating septa (in the species at present known) about twenty-four. Tabulæ thin and apparently, in some instances, not complete. When the corallites are not in contact, the space between them is filled with a variously formed vesicular tissue. This genus re-

sembles *Heliolites*, but differs therefrom in having double the number of septa and the walls perforated.

C. CANADENSIS.—This species forms small hemispheric or irregular masses with the corallites about one line, usually a little more, in diameter and generally in contact although still remaining circular. Three tabulæ in one line, in the specimens examined. Mural pores in horizontal rows running all round the tube, one row between each two tabulæ. It occurs in the Black River limestone near Ottawa. E. Billings.

C. HURONENSIS.—Corallites somewhat less than one line in diameter with a few others much smaller between them. They are, in the same colony, in some places so closely crowded as to become nearly hexagonal and elsewhere either in contact or separated half their diameter from each other. The only specimen collected seems to be a part of a tuberoso mass. It is closely allied to *C. Canadensis*, but has the corallites, in general, more slender, and presents a different aspect. Hudson River formation, Cape Smith, Lake Huron. Prof. R. Bell.

C. ANTICOSTIENSIS.—Corallum forming depressed hemispheric masses. Corallites a little more than one line in diameter with smaller ones between them, sometimes in contact, but, in general, distant from one-fourth to one-half their diameter. Costæ forming a fringe around the apertures and also seen in vertical polished sections. Intercellular tissue composed principally of thin, undulating or flat horizontal diaphragms extending from tube to tube and subdivided into square cells by the costæ at the surface of the walls. Tabulæ obscurely seen, in the specimens observed, apparently very thin. There are about three diaphragms and tabulæ in one line. The radiating septa form thin, sharp, strong, elevated striæ on the inside of the tubes where exposed in weathered specimens. Closely allied to the two last, but has the corallites, in general, somewhat larger and more distant. West side of Gamache Bay, Anticosti; Division 1; Anticosti group; Middle Silurian. T. C. Weston.

Genus HELIOLITES, Dana.

II. SPECIOSUS.—Corallum clavato-turbinate or sub-pyriform; cells a little more than one line in diameter, on an average, usually about half their width distant from each other, but occasionally in contact and sometimes more widely separated; their margins thin, elevated above the general surface, crenulated or ornamented with twelve small rough tubercles. The septa seem to be only incipiently

developed, but they can be distinctly seen in the inside of the cup as so many small vertical ridges; there appear to be twelve of them. The tabulæ are somewhat irregular, being either horizontal, oblique, flat, convex or concave, from two to four in one line. The cœnenchyma is composed of small vesicular cells from one-sixth to one-third of a line in diameter. The surface between the cells is, when perfectly preserved, covered with small rough tubercles. When the specimens are worn, the surface presents only the circular apertures of the cells and is destitute of granulation.

Only six specimens of this species were collected, and they are all of the clavato-turbinate form. It is possible that hemispherical or globular colonies may exist as there is much variety in the form in species of this genus. Some of the cells are nearly two lines in diameter, others less than one line.

By the size of the cells this species is distinguished from all others of the genus except *H. megastoma* (McCoy) and *H. macrostylus* (Hall). From these it differs in the structure of the tissue between the tubes. In *H. megastoma* the cells of the cœnenchyma are arranged in polygonal columns. Such, also, seems to be their structure in *H. macrostylus*. The species which Edwards and Haime have placed in their genus *Lyellia*, *L. Americana* and *L. glabra*, have the tubes rather more widely separated and the septa more strongly developed. Occurs at Junction Cliff, Anticosti; Division 1; Anticosti group; Middle Silurian. T. C. Weston.

H. AFFINIS.—Corallum hemispheric, globular, pyriform, clavato-turbinate or tuberoso, sometimes incrusting other fossils in a thin layer; cells usually circular, often sub-polygonal, in contact with each other or barely separate, from half a-line to little less than one line in diameter, the more common width being about two-thirds of a line, their margins thin, distinctly elevated above the general surface, and, in perfect specimens, crenulated or serrated with twelve small, rough, pointed tubercles. Septa rudimentary, rarely visible but in certain conditions of preservation distinctly striating the inside of the cells and tubes below. The tabulæ are usually horizontal, three or four in one line. Owing to the close arrangement of the tubes there is very little cœnenchyma, and this is vesicular.

When the cells are closely crowded together they become more or less prismatic with polygonal apertures, and, it is then difficult to distinguish the specimens from certain species of *Favosites*. In general, however, they are circular although in contact or nearly

so. Colonies are occasionally found with the cells distant about half their diameter.

The species to which this is most nearly related is *H. tubulata* (Lonsdale), common in the Wenlock limestone. That species however, as described by McCoy, Edwards and Haime and others, has the cells in general somewhat smaller and the apertures not so strongly serrated.

The crenulations on the margins of the cells are only visible when the surface is not at all abraded. The least wearing removes them, and the apertures are then simply circular or sub-polygonal.

This species has been found at Wreck Point, Anticosti; in the Hudson River formation. Also at White Cliff, Junction Cliff, Walls Cove, South Point and other localities, on the same island, in Divisions 1, 2 and 3; Anticosti group; Middle Silurian. J. Richardson and T. C. Weston.

H. EXIGUUS.—Cells about half a line in diameter and somewhat more than their own width distant from each other, with thin elevated margins, apparently not crenulated. Septa not visible in the only specimen collected. Tabulæ numerous, four to six in one line. Cœnenchyma minutely vesicular.

As the specimen is somewhat worn, it is possible that the margins of the cells when perfect may be crenulated. The cœnenchyma appears to be vesicular, but more specimens are required to decide this point.

This species, on account of the small size of the cells and their greater proportional distance from each other, seems to be distinct from all the others.

H. SPARSUS.—Cells varying from half a line to one line in diameter, distant from one to three lines from each other. Radiating septa much developed, sometimes meeting in the centre. The cœnenchyma varies in structure, being in some places entirely vesicular, and elsewhere composed of vertical series of square cells as in *H. megastoma*. These variations are seen in the same specimen. Chicotte River, Anticosti; Division 4; Anticosti group; Middle Silurian. J. Richardson.

H. TENUIS.—Cells, in general, a little less than half a line in diameter, and half their own width distant. The walls are excessively thin and rarely distinguishable, not forming a distinct ring as in the others above described. Cœnenchyma, as seen upon the surface, composed of minute polygonal cells. This species may,

perhaps, belong to the genus *Protarcea*. Gamache Bay, Anticosti; Division 3; Anticosti group; Middle Silurian. T. C. Weston.

Genus FAVOSITES, Lamarek.

F. PROLIFICUS.—Corallum forming large hemispheric or irregularly convex masses. Tubes about one line in diameter. Tabulæ thin and either complete or imperfect, sometimes filling the tube with vesicular tissue. They are often very numerous, there being sometimes six or seven in one line. No septa or mural pores have yet been detected, and it may be that this species should be placed in another genus. Hudson River group and throughout the Middle Silurian; Anticosti. J. Richardson and T. C. Weston.

Genus STENOPORA, Lonsdale.

S. BULBOSA.—This species is found in small globular or subpyriform masses from six to thirty lines in diameter. There is often a small shell buried in the base. The tubes are about the size of those of *S. petropolitana*. Gamache Bay, Anticosti; Division 1; Anticosti group; Middle Silurian.

Genus PETRAIA, Munster.

P. OTTAWAENSIS.—Turbinate and either straight or more or less curved, enlarging to a diameter of about an inch in a length of two and a-half inches, irregularly constricted at various intervals and usually engirdled with fine wrinkles. There are, apparently, about fifty principal septa with smaller ones between, where the diameter is about one inch. Cup, nine lines in depth. Differs from *P. corniculum* in the irregularity of its surface. Ottawa, Trenton formation. E. Billings.

P. SELECTA.—Base acutely pointed; above, rather slender for the first few lines, then more rapidly enlarging. Depth of the cup about two-thirds of its width at the margin, septal striæ four or five in two lines. The plane of the margin of the cup is, in all the specimens I have seen very oblique, always inclining towards the curved side. Length of largest specimen seen fifteen lines; width of cup twelve lines. In general, the individuals are more slender. West end Lighthouse, in the Hudson River formation; also at Gamache Bay, Anticosti; Division 1; Anticosti group; Middle Silurian.

P. PULCHELLA.—The two specimens on which this species is founded are acutely pointed and moderately curved. The following are their dimensions. One of them is nine lines in length and six

and a-half in diameter at the margin of the cup. The other is ten lines in length and seven in diameter. There are about sixty septa in each. In a polished longitudinal section, the cup is found to extend about half the length of the whole fossil downwards and to have a conical elevation in the centre. The septa, above the bottom of the cup extend inwards about one line gradually diminishing in height to the margin. Junction Cliff and White Cliff, Anticosti; Division 1; Anticosti group; Middle Silurian.

Genus ZAPHRENTIS, Rafinesque.

Z. PATENS.—The specimen is broken off at nine lines below the margin of the cup. Diameter of the lower extremity, twenty-one lines, and of the cup at the margin, thirty-three lines. It thus expands, in this part, one inch in a length of nine lines. It may have been more cylindrical below. In the cup there are thirty-six large septa nearly three lines apart at the margin. Between these are thirty-six smaller ones, which are scarcely half a line in height, and have their edges serrated with small denticulations about three in one line. There is a deep septal fossette on one side. Surface and lower parts unknown. Cormorant Point, Anticosti; Division 3; Anticosti group; Middle Silurian. J. Richardson.

Z. AFFINIS.—Three or four inches in length, expanding to a diameter of eighteen lines at the height of three and a half inches, moderately curved, sometimes with strong irregular annulations. In a polished longitudinal section the tabulæ are seen to be thin flexuous, closely crowded together and extending all across or nearly so. There are about two septal striæ on the surface in one line, and thus, where the diameter is eighteen lines there must be, at the margin, about one hundred septa. In part of a weathered cup some of the septa run along the upper surface of the tabulæ nearly to the centre. This species is allied to *Z. Canadensis*, but differs in having the principal septa more developed and in its more irregular growth. The cup has not been seen. It is possible that this and *Z. Canadensis* may belong to a different genus, perhaps to *Omphyma*. Wreck Point and White Cliff, Anticosti. In the Hudson River group and in Division 1; Anticosti group; Middle Silurian. T. C. Weston.

Z. BELLISTRIATA.—Turbinata, gradually enlarging from an acutely pointed base, moderately and sometimes irregularly curved. There are about sixty septa where the diameter is one inch. Many of these, in the lower part, reach the centre, but above

the height of two inches, (as shown by a polished section of a specimen) the central area is filled with irregular tabulæ. The cup, in a specimen four inches in length, is eighteen lines in depth, conical, or much narrowed towards the bottom. Surface with five strong, rounded septal ridges in the width of three lines. On approaching the base these are more closely crowded together than they are in the higher and main body of the coral. They are crossed by fine engirdling striæ just visible to the naked eye. Length of the largest specimen observed four inches. Numerous small straight individuals from one inch and upwards occur with the larger. Wreck Point; in the Hudson River group; and, also, in numerous localities in Divisions 1 and 2; Anticosti group; Middle Silurian. J. Richardson and T. C. Weston.

Genus ERIDOPHYLLUM, Edwards and Haime.

E. VENNORI.—Corallites about two lines in diameter and either in contact or at various distances from each other up to two or three lines. The normal distance appears to be about one line, but where the corallites are crooked, as they are in one of the specimens collected, considerable variations occur. There appear to be from twenty-four to thirty septa, some of which meet in the centre. The tabulæ are imperfectly developed, but are seen, in some of the corallites, forming with the septa square cells near the margin. The connecting processes are from one to three lines apart. Surface with obscure septal striæ and transverse undulations. This species may form the type of a sub-genus, differing from the above in the greater development of the septa and rudimentary tabulæ. Manitoulin Island; Clinton formation. Prof. R. Bell, and H. G. Vennor; dedicated to the latter.

Genus CHONOPHYLLUM, Edwards and Haime.

C. BELLI.—Sub-turbinate, enlarging from a pointed base to a diameter of eighteen lines in about two inches, then becoming more cylindrical. Length three or four inches; greatest diameter observed, at the cup, thirty lines. Cup, in the largest specimen seen eight lines wide and six lines deep with slightly sloping walls, apparently flat in the bottom with the exception of a rough styliform projection in the centre; edge of the cup narrowly rounded, a broad flat or gently convex margin all round which is nearly horizontal or slightly sloping outwards and downwards. In the inside of the cup there are about seventy thin, sharp, slightly elevated septa, alternately larger and smaller. These, in radiating

outwards across the broad, flat margin to the periphery, are gradually changed into rounded ribs, some of them half a-line wide. The body of the fossil, as shown in several weathered and silicified specimens is composed of numerous irregular infundibuliform layers which are, in some places, in contact, and elsewhere, separated, sometimes three lines apart. Surface, unknown. This species shows that *Chonophyllum* and *Ptychophyllum* are closely related genera. East side of the village in the bight of West Bay, Manitoulin Island; Clinton formation. Prof. R. Bell, H. G. Vennor. Dedicated to the former.

THE NATURAL HISTORY OF THE SANGUINARIA CANADENSIS, OR CANADA BLOODROOT.

By GEORGE DUNCAN GIBB, M.A., M.D., LL.D., F.G.S.: Member of the Royal College of Physicians in London; Assistant Physician and Lecturer on Forensic Medicine at Westminster Hospital.

In January, 1860, I had the honor to read before the Medical Society of London, a lengthy paper upon the Natural History, Properties, and Medical Uses of the *Sanguinaria Canadensis*, with the chief object of making the medical profession in Britain acquainted with a plant which I had employed for some years, with decided advantage, in many affections of the chest and windpipe. My observations were the result of many years study of the plant in Canada, where I had made myself familiar with everything concerning its growth and natural history.

That part of the paper comprising the description, composition, and preparations of the *Sanguinaria* was published in the *Pharmaceutical Journal* for March, 1860; the account of its physiological effects, properties, and medical uses appeared in the *Glasgow Medical Journal* for July, 1860; whilst that portion relating to its natural history has not yet been published. Having carefully revised this last, it has occurred to me that the most suitable place for its consideration would be the Natural History Society of Montreal, a body on whose behalf I zealously laboured as curator for some years, before taking up my residence in London.

As far as traditional evidence can be traced, this plant has been used for hundreds of years by the various Indian tribes of North

America, as a pigment, a dyeing agent, and a medicine. For what maladies it was originally given as a remedy, it is impossible now to determine. Charlevoix appears to be the first writer who mentions its employment as a medicine, when using the expression, “s’est souvent servi de la racine de cette plante pour provoquer les mois,” in other words it was administered as an emmenagogue. The first printed notice of the plant is briefly given in the “*Historia Canadensium Plantarum*” by Jac. Cornuti, Paris, 1635. He describes it as the *Chelidonium maximum Canadense* *αχαιλον*,—receiving this name, he observes, from its similitude to the *Chelidonium* species of plant, and from its flowering in the spring.

The second notice of it occurs in a curious old book, entitled “*Theatrum Botanicum, or the Theatre of Plants*, by John Parkinson, apothecary, London, 1630.” At page 617, is given an erroneous description of the plant, but under the same name as that adopted by Cornuti, and styled in English, the “Great Celandine of Canada.” Singularly enough, however, at page 327, the actual plant itself is very correctly given with woodcut, and wrongly named *Ranunculus Virginiensis albus*, the white Virginian Crow-foot. The error thus committed did not escape the notice of a subsequent writer, of whom I shall presently speak. It cannot be positively inferred from Parkinson’s writings that the plant was cultivated in England; probably it was, and seen by Parkinson himself, else he could have hardly given such an accurate account of it. Morrison, however, settles the point of its early culture in that country, when he states that seeds of the plants had been sent to him from Canada and Virginia, which had propagated abundantly in a suburban garden near London.

Charlevoix—no mean authority in anything pertaining to Canada—has adopted Cornuti’s name in his description of the plant, and moreover styles it the Dragon’s Blood of Canada, “*Sang Dragon du Canada*.” He gives a more correct account and extended description of it than Cornuti, and a woodcut somewhat more accurate than that given by Parkinson.

The clearest and most accurate description, however, of this interesting plant, is to be found in the “*Hortus Elthamensis seu Plantarum Rariorum*,” of Joh. Jac. Dillenius, in which several figures of the plant are given, colored most naturally, under the name of *Sanguinaria major et minor*. The name was derived from *Sanguis*, blood, from the blood-red color of the juice which flows from the rhizome and petioles when wounded. On looking

at this splendid work for the first time in the Library of the British Museum, I found the illustrations to be perfect imitations of the plant, as it presented itself to my notice hundreds of times, growing wild in the woods and mountains of Canada. The plate in Charlevoix's book gives an idea of the plant, and is correct in many particulars ; but on comparing it with that of Dillenius, the leaf is not altogether so natural, being too much serrated, and perhaps the root is too insignificant. Any one, however, familiar with the plant would observe that Charlevoix meant it for that, and must have seen it himself. Dillenius speaks of the plant as vulgarly named *Chelidonium Canadense*, and says the thick and fleshy roots are not unlike *Tormentilla*. He has freely entered into its previous history, and shows the errors into which writers—especially Parkinson—previous to his time (1732) had fallen regarding this plant. In 1731, the year before the great treatise of Dillenius was published, appeared Catesby's large work on the Natural History of Carolina.

The first introduction of this plant into Europe was through the return to France of some of the earlier travellers through Canada. It was cultivated in the gardens of Paris, and this enabled Cornuti to describe it, from recent specimens, in 1635. Many persons have believed, from the title of his work, that Cornuti had travelled in Canada ; nevertheless, it is quite certain, that he never was there. The foreign plants he describes may have been from Canada, or other parts of the New World, which he had observed growing in various gardens in Paris. The plants described by Charlevoix, in 1744, which he met with in Canada, in 1721-22, are considered in the first volume of the Transactions of the Literary and Historical Society of Quebec by Mr. William Shepherd, who took the pains to identify them with the nomenclature now in use. This was highly necessary, because some of Charlevoix's descriptions were imperfect and vague ; this was so, to a slight extent, with the Blood-root, which had been named by Linnæus some years before Charlevoix published his History of New France. Its Linnæan name soon spread in America, for we find Kalm mentioning, in his travels in that part of the world, under date, " April 6th, 1749, *Sanguinaria Canadensis*, which is here called Blood root—because the root is great and red, and when cut looks like the root of red beet—was beginning to flower, growing in a rich mould." This was in New Jersey.

BOTANY.—The *Sanguinaria* belongs to the sexual system *Poly-*

andria Monogynia, and the natural order *Papaveraceæ*. (It was placed by De Jussieu in his natural order *Papavera*, and by Necker in the *Catizophita*).

GENERAL CHARACTERS.—The Calyx (flower cup) is ovate and concave, has two sepals shorter than the blossoms, and falls off very early. The corolla (blossom) consists of eight petals, but varying from seven to fourteen, which are spreading, oblong, obtuse, concave, narrowed at the base, mostly white, but sometimes tinged with rose or purple. The stamens are numerous (said to be twenty-four) and unequal, and comprise many simple yellow filaments shorter than the blossom (one-half or one-third the length of the petals), with oblong, linear, and innate orange anthers. The pistil is composed of an ovary (germ or seed bud) of an oblong and compressed form, with no style, but with a sessile, thick, persistent stigma, possessing a striated double groove, and is of the same height as the stamens. The pericarp (fruit or seed vessel) is superior, and has an oblong and bulging pod-like capsule about an inch or more long, tapering to a sharp point at both ends, two-valved, forming a single cavity, filled with numerous oval, reddish-brown seeds. The valves of the capsule are caducous, the columella double and permanent. Receptacles or placentas two, filiform, marginal, and persistent.

SPECIFIC CHARACTERS.—The rhizoma is horizontal, creeping, abrupt, often contorted, half an inch in diameter or about as thick as the finger, two to four inches long, tuberous and perennial; reddish-brown color on the outside and brighter red within, discharging when wounded an acrid, orange-red coloured juice, with a number of long slender radicles, and makes offsets from the sides, which succeed the old plant. There is no aerial stem. From the end of the root arise the scape and leaf-stalks (rarely a pair of leaves) surrounded by two or three large membranous sheathing scales of the bud, at their base. These spring up together, the folded leaf enveloping the flower bud, and rolling back as the latter expands. The petiole (leaf stalk) is from two to six inches long, slender, round, and glabrous. The leaf, which stands upon a long channelled petiole, is radical, reniform, united at the base, somewhat heart-shaped or cordate-reniform, serrated, deeply or palmately lobed, the lobes entire, or repandly toothed, very smooth, of a pale yellowish green (sometimes quite dark) on the upper surface, and glaucous or bluish-white and strongly reticulated by orange colored veins. The scape is erect, round and smooth, often of a

purplish color, rising from a few inches to a foot, and terminating in a single flower. Flowers are simple, terminal and white, from one to one and half inches in diameter. Sepals two, deciduous. Petals eight naturally, but increased by cultivation. Stamens numerous. Style none. Seeds numerous, dark, shiny, reddish-brown, half surrounded by a white vermiform appendage. The whole plant is pervaded by an orange-colored sap, which flows from every part of it when broken, but is of the deepest color in the root.

The *Sanguinaria* cannot be considered a handsome showy plant, nevertheless its humble but beautiful little white flower, and the extreme delicacy of its leaves curiously veined on the under side with a pale orange, at once strikes the observer. With justice it may be called elegant, and can be admired not only for its delicacy, but is interesting from the circumstance of its very early inflorescence, being among the earliest of the spring plants of North America, appearing as soon as the frost leaves the earth, in the months of April and May.

Generally in the month of April, in Canada and Northern States of America, as soon as the sun has warmed the earth and loosened it from its frozen bonds, a number of milk-white buds, elevated on a naked foot-stalk, partially enveloped in a handsome vine shaped leaf may be seen. The flower is at first embosomed in the young convolute leaf and rises in front of it, and long after inflorescence the reniform and lobed leaves, covered with their wax-like veins continue to grow. At first a single leaf and flower generally proceed from each bud of the tuber, enveloped at the base with glaucous and somewhat succulent sheaths. Both the leaf-stalks and scape, which are thus encircled at their origin from the root by a common sheath, are of an orange color, deepest towards their junction with the caudex, and becoming paler near to the leaves and flowers, where it is blended with green. When broken or squeezed, they emit a colored liquor, like that of the root, but paler. The stain of this fluid on paper is a faint yellow; that from the root is much darker. As it appears southward, it flowers in March, and in the states of South Carolina, Georgia, and Florida, it flowers in February.

The Flower resembles the white crocus very closely, for when it first comes up, the bud is supported by the leaf and is folded together with it; the flower, however, soon elevates itself above its protector, while the leaf, having performed its duty of guardian to the tender bud, expands to the full size. The scape,

which is uniformly terminated by a single flower, proceeds from one end of the root, and rises perpendicularly to the height of six or eight inches. The flowers are much under this height at the early part of the season; and not unfrequently they are expanded at those periods when the scape has just appeared above ground. By the time the flower is expanded and spreading, the leaf-stalk is not more than half the length of the scape. The flowers possess two deciduous calyx leaves. Michaux says there are three; this is clearly an error. The calyx is so exceedingly fugacious, that it is common for them to fall off before the flower is expanded, hence they are rarely seen.

The flowers have generally but eight petals, varying in size; I have seen them of ten and twelve, and they have been counted from seven to fourteen. They are not, therefore, double. With care, some fine double varieties might be produced, as there is a great propensity in this plant to multiply its petals in favorable situations.

There are, probably, two varieties of the *Sanguinaria*, founded upon the difference in the form of the petals. One of these is described by Pursh, in his *Flora*, as having the petals of a linear form; the same peculiarity being noticed by Mr. Lyon of Georgia. The petals, which are for the most part pure white, are often tinged on their under side, and sometimes on their upper, with a delicate rose color. Occasionally a purple tinge replaces the rose. The flower bud is generally rose-colored. The pistil is reddish green. During the heat of the day, the petals are horizontal and spread out; they converge towards the evening, and at night are wrapped up; the leaves, also, partly close towards night.

At the end of a few days, the petals fall, and leave a small rudimentary pod or capsule. This continues to grow till it has attained from one to two inches in length, and when they have become ripe, they turn slightly brown, curl up, and discharge the seeds. This occurs at the end of May or during June, sometimes as late as July. The number of seeds varies from ten to sixty in each capsule.

When the flowering has passed the whole plant becomes much increased in size, frequently attaining by mid-summer, to the height of fifteen inches, but commonly not exceeding twelve. The leaves, having continued to grow, have acquired so large a size as to appear like a different plant, exceeding in dimensions that first observed twice, thrice and four times. During flowering,

time the leaves are about two inches wide, and are divided by a couple of sinuosities, giving them, when spread out, a reniform or heart shape, with large rounded lobes separated by obtuse sinuses; but as they increase in size, the sinuosities either remain simply two, or increase up to seven in number, extending half way to the base.

The number of leaves varies from two to six, and several flower stalks are furnished from a single root. The number of flowers depends upon the number of buds or hybernaculæ, usually from three to four; but when the flowering is over, the leaves spring up in profusion.

A single bud terminates the root, but as the root makes offsets from its sides, several buds are formed, which separate as the old root decays, acquiring by this separation the abrupt or premorse form commonly noticed. The hybernaculum is composed of successive scales or sheaths, the last of which, as mentioned before, acquires a considerable size as the plant springs up. If the hybernaculum is dissected in the summer or autumn, the embryo leaf and flower of the succeeding spring may be discovered, and with a common magnifier, even the stamens may be counted. This peculiarity adds greatly to the interest of the plant, which some botanists declare is scarcely known to be equalled in point of delicacy and singularity, from the time its leaves emerge from the ground, and embosom the infant blossom, to their full expansion, and the ripening of the seed vessels.

The plant has been successfully grown in various parts of Europe, and is an object of attraction and interest to the florist. Still it is very little known in Britain, and is not even mentioned in many of the systematic works on Botany.

Its height, as before stated, varies from five or six inches to upwards of a foot: this will vary according to its geographical position and also to the nature of the soil in which it grows. A dry wood, with fertile soil, is its favorite seat; but on the borders of rich, shady woods and clearings, and on the declivities of hills in a shady situation, and in a light vegetable mould, it thrives and propagates most abundantly, as well as being seen to perfection. It grows also in the shade on a rocky soil, partly covered with light earth, composed principally of decayed leaves. Dr. Barton speaks of it in an arid sandy soil, near the University of Pennsylvania; whilst Pursh says it delights in fertile soil. Moreover, it is found in places where the soil is positively

bad, thus showing that it is a hardy perennial. It is never found in open cleared land, or if a plant is there seen, it is small, stunted, and soon dies out. It may be converted into an annual by parting its roots in the autumn, when it will blossom in the beginning of April, and its seeds will ripen perhaps before June. In England it flowers in the beginning of April, as in Canada; its blossoms are fugacious, and fully expand in fine warm weather. Sometimes, in Canada, the flowering may be tardy, if the spring is unusually late; but, as a rule, the moment the snow disappears this charming little plant shows itself and flourishes luxuriantly.

The *Sanguinaria Canadensis*, or Bloodroot, possesses several names derived from its leading peculiarities and uses. It was called Bloodwort, Bloodroot, Bethroot, and *Sanguinaria*, from the circumstance of its fleshy roots pouring forth a bright red or orange juice when broken asunder. The color may, perhaps, be pronounced an orange scarlet. This juice is used by the Indians, as a dye, and as a paint, to smear their bodies, and hence called Indian Paint, Indian Turmeric, Puccoon, Red Puccoon, Red Root, &c. The juice pervades all parts of the root, and exudes from a cut or wound on any part of it. It also follows on cutting the leaves and footstalks, but to a smaller extent. In Charlevoix's time the juice was preserved for the purpose of staining furniture.

HABITATION.—Canada is essentially the country of the Bloodroot; hence its name, especially as it was first discovered in that part of the British Empire. It grows in abundance throughout the woods of Canada, and is found plentifully on the shores of Lake Superior. I believe it will be found as far eastward as Labrador, and to the north of the Saskatchewan, on the eastern side of the Rocky Mountains.

It exists throughout the United States, south of Canada, and is found as far as Florida. Professor Barton says, it is found everywhere west of Delaware. And in the course of my investigations into the history of the plant, I find that it luxuriates in every State throughout the great American Union, possibly somewhat varying in its general characters.

The *Sanguinaria* was found in the eastern woody district, or first of the subdivisions of the First Zone, described by Sir John Richardson, in the journal of his Arctic Searching Expedition, in search of Sir John Franklin. "This zone extends over the

eastern side of the continent from latitude 45° to 55° ; it comprehends the St. Lawrence and Saskatchewan basins; it rises obliquely, in accordance with the course of the isothermal lines, in going westward, and on the Pacific coast it includes the 49th and 58th parallels, or Vancouver's and Sitka Islands. It is subdivided into three districts; viz, the eastern forest country, the eastern prairies, and the country west of the Rocky Mountains" (p. 320).

It extends a little north of the western part of the Province of Canada. I am informed by those who have resided there, that they have seen it used by the Indians of the Red River; but my friend, the late Mr. Peter Dease, of Montreal, stated it is not found north of that river. He also observed that it is unknown at Hudson Bay—an observation corroborated by Sir John Richardson. The extreme western range of the plant probably extends to Oregon Territory and California, far to the west of the Mississippi and the Missouri Rivers. The geographical range, therefore, of this plant is most extensive, being found many thousands of miles, over a large proportion of the North American continent—its extreme southern limits being the state of Florida, the most southern in the American Union.

The seeds obtained by Morrison, prior to 1680, were from Canada and Virginia; and Dillenius mentions, in 1732, that Blood-root was a native of Canada, the New England States, Pennsylvania, Maryland, Virginia, and Carolina. Subsequent writers and travellers have still further shown its great range.

The remarkable peculiarity therefore associated with this interesting plant, of a wide and extended range over so large a portion of the North American continent, cannot escape notice. It would appear to grow in rich or scanty soil, overlying strata of diverse and various geological epochs. It flourishes in abundance in the vegetable and woody soil above the Silurian rocks, both upper and lower, of Canada, and on their predecessors the granites and Laurentian rocks of Canada, and those to the north-west of Carolina, Georgia, and the north-east of Alabama. The trap mountains of Canada, especially the Montreal, the Belœil, the Montarville and Mount Johnson, are extremely favorable to its growth. The Devonian rocks and the Carboniferous series of the States of Illinois, Michigan, Ohio, Pennsylvania, Virginia and Kentucky, as well as those of Canada and New Brunswick, are well covered by it. It is even to be found along the thin belt of New Red

Sand stone which skirts the Connecticut valley, and running in a direction of north-east and south-west. Lastly, the soil overlying the cretaceous groups of Alabama, Mississippi, Arkansas, and other States, and the great alluvial tertiary deposits which skirt the eastern shores of those States, along the Atlantic borders from New Jersey, southwards to Florida, comprising the whole of the latter State, and thence spreading along the northern shores of the Gulf of Mexico, taking in portions of Alabama, Louisiana, and Texas, contains this plant in not less abundance than in the more northern regions.

The growth of the *Sanguinaria* in soils, covering, and at the same time derived from so many distinct formations, proves in a remarkable manner the natural hardihood of the plant; but, I think I am not in error in stating, that its growth is particularly favored by the soils derived from the various rock formations of Canada, which comprise the oldest known of our globe.

It is a plant, like many others, which has flourished subsequently to the existence of the most recent tertiary formations, as no evidence of its presence, nor of any member of its family, the *Papaveraceæ*, has been afforded in a fossil state.

When we consider what small and easily destructible plants those are which pertain to the order to which this plant belongs, it will not surprise us that no vestiges of their former existence are left on our planet. Whether they ever will be discovered remains a problem which time only can solve. If my zeal for the *Sanguinaria* will not be considered as carrying me too far, I am disposed to believe it flourished anterior to the last deposition of the Tertiary strata; but from the perishable nature of the materials which belong to the poppy tribe generally, no relics have been left behind.

1 Bryanston Street, London, October 11, 1865.

OBSERVATIONS ON THE DRIFT PHENOMENA OF LABRADOR.

By A. S. PACKARD, Jr., M.D.

The whole surface of Labrador has passed through a denudation of great extent by continental glaciers. In the southern

part of the peninsula, bordering on the gulf of the St. Lawrence, the glaciers evidently moved southward down the slope from the water-shed in the interior. On the eastern or Atlantic coast, at both sides of the mouth of Hamilton Inlet, which is forty miles wide, there are glacial lunoid furrows, like those observed in Maine by Dr. Delaski, which tend to prove by their direction that a glacier forty or fifty miles in breadth filled this great fiord, and moved in an easterly direction from the water-shed in the interior, thence debouching into the sea.

Owing to the powerful disrupting agency of the frost and ice, the rounded and denuded rocks of Labrador have as yet revealed but few glacial striæ. The distribution of the boulders is restricted to the higher levels of the plateau. To find them in any abundance, it is necessary to ascend from 500 to 800 feet above the sea, where they occur in profusion. Below this they have been rolled, rounded, and rearranged into ancient sea beaches. But on the smooth polished quartzites and syenites, the former of which are levelled into broad plains grooved and furrowed and afterward polished almost like glass, with shallow depressions, being glacial troughs filled with water, and forming countless pools, and on the rounded syenitic hills which assume dome-like or high conical sugar-loaf forms, we see everywhere in Labrador, below a level of 2000 feet, the traces of ancient glacier action exhibited on a vast scale.

At the close of the Glacial epoch the moraine matter was reassorted into marine deposits, which in this country have been exposed to a general and sweeping denudation. Only small patches are found remaining in sheltered positions. These marine deposits consist of finely laminated clays resting upon coarser, more stony, and gravelly beds. The former were evidently estuary deposits, the latter thrown down in deeper water, where the strong Arctic current prevailed. The oldest beds are the coarser strata, which, as in Maine, occur at high-tide mark. The more recent beds occur from ten to twenty feet above the sea level.

The fossil Invertebrata, found abundantly in these beds, afford excellent material for comparison with the present marine fauna of Labrador, and throw new light on the distribution of marine life during the close of the Glacial epoch. The assemblage is thoroughly Arctic in character, but, when compared with lists of the glacial shells of the north of Europe, it is found to bear a

very distinct *facies*. It is evident that on each side of the Atlantic, the same faunal distinctions obtained during this period as now. There was, however, a greater range in space of purely Arctic species, and, though the European marine fauna was much more closely allied to our own, owing to the great predominance of exclusively Arctic forms, it is yet evident that the Arctic glacial fauna was divided into a Scandinavian district, and a Labrador district, each the metropolis of a small number of species peculiar to itself and limited to its area.

The assemblages found at various points along the coast from Labrador to Maine are not the exact equivalents of the present faunæ. They differ in containing a very small percentage of extinct species, and in a different grouping of species still living.

Thus, in the Labrador beds are several species of *Fusus* which differ from recent Arctic forms, and also a species of *Bela*; certain forms, such as *Panopœa* and perhaps *Cyrtodaria*, which were abundant formerly, seem to be dying out at the present day. In Maine the change is still more marked. Thus, the most characteristic shell of the marine clays is *Leda truncata* (*Portlandica*), which has wholly disappeared from the seas south of the circum-polar regions, unless future deep-sea dredging reveals its presence in some of the abysses off our coast. An undescribed *Macoma* is also characteristic of the beds about Portland; and other important changes have occurred in the relative abundance of species, and the manner in which they are grouped as compared with the present assemblages in zoological districts farther north, and similar in physical surroundings to the glacial seas.

The Labrador district of the Arctic fauna, instead of being restricted as now to the eastern coast of North America from the Arctic archipelago to the banks of Newfoundland, and shading off into the Acadian district at the present line of floating ice, during the Glacial epoch extended up the St. Lawrence river, and as far as Portland, on the coast of Maine, where it shaded into a more southern assemblage.

In Maine there are two distinct horizons of life. The lowest and oldest is found at the bottom of the boulder-clay at high-tide mark along the coast. The second horizon is composed of reworked, finely laminated, less stony clays occupying the coast from 25 feet above the sea level to a height, 50 to 100 miles inland, of nearly 300 feet. The species found in this second horizon are rather boreal forms than purely Arctic. In the beds

about Saco and Scarboro we find *Leda tenuisulcata* intermingled with the Arctic *L. permula*, as it is not at present on the coast, and *Pandora trilineata* replaces the Arctic *Pandorina arenosa*. At Berwick, *Astarte castanea*, a boreal form, is introduced; while south of this, at Point Shirley, Desor and Stimpson found *Nassa trivittata*, *Buccinum plicosum*, *Astarte castanea* and *Venus mercenaria*, species which now, as an assemblage, abound most on the shores of New England south of Cape Cod, and in New York bay. Again, at Nantucket, Desor found a still warmer fauna occupying, apparently, an extension of this second horizon. *Arca transversa*, *Crepidula fornicata*, with *Buccinum plicosum* and *Nassa obsoleta* were found to abound in this locality, where the warming influence of the Gulf Stream was strongly felt, while the waters of Maine were cooled down by the Arctic or Polar current.

In the beds of this horizon at Gardiner, occur the teeth of the bison, walrus, and bones of other animals, and the *Mallotus villosus*; also in the same beds at Bangor the fossil whale, and in Burlington, Vt., in the Champlain clays, which evidently belong to this horizon, the *Beluga Vermontana* of Thompson.

Thus the two glacial faunæ that have successively gained a foothold in northeastern temperate America, seemed, as regards both their land and marine animals, and also plants (for *Potentilla tridentata* which is found only in Maine, Labrador and Greenland, is also found fossil in the Ottawa clays, according to Dr. Dawson,) to be a purely Arctic American assemblage.* According to the view of Dr. Hooker,† the most ancient glacial flora was derived from Scandinavia. On the contrary, as far as geological evidence at present tends, the cave mammals of Europe were associated with the musk ox, reindeer, white bear, and other Arctic animals which abound in Arctic America, while no features in the Post-tertiary fossils of America seem to be European. These faunal distinctions would seem to be even more strongly marked than now in the distribution of the Vertebrata during the closing part of the Glacial epoch.—*From Silliman's Journal.*

* [Scarcely "arctic." See Dr. Dawson's paper in Jour. Geol. Soc., London, Dec., 1865. Eds.]

† Trans. Linn. Soc. London, xxiii, part 2.

BRITISH ASSOCIATION.

FIRST REPORT OF THE COMMITTEE FOR EXPLORING KENT'S
CAVERN, DEVONSHIRE.

The celebrated Kent's Cavern, or Kent's Hole, is about a mile due east from Torquay harbor. It is situated in a small wooded, limestone hill, on the western side of a valley, which, about half a mile to the south, terminates on the western shore of Torbay.

The hills which surround the district consist of limestone, green-stone, clay-slate, and a reddish grit or compact sandstone. The two last are traversed by veins of quartz: and, with the possible exception of the greenstone, they all belong to the Devonian system. Indeed, the entire Torquay peninsula is exclusively made up of rocks of this age.

According to tradition there were formerly four or five entrances to the cavern, of which two only were generally known; the others being merely narrow apertures or slits through which, until they were blocked up from within, the initiated were wont to enter clandestinely. The remaining two are about fifty feet apart, and occur in the face of one and the same low natural cliff, running nearly north and south, on the south-eastern side of the hill. The northern entrance is in form a rude triangle, about six feet high and eight feet wide at the base. The southern is a natural and tolerably symmetrical arch, nine and a half feet wide at the base and six feet high. Its form is due partly to a small curvature of the strata—the apex of the opening being in the anticlinal axis—and partly to the actual removal, by natural causes, of portions of the limestone beds. The base of the opening, or chord of the arc, consists of undisturbed limestone, so that the entrance may be aptly compared to the mouth of an oven.

From the time of the researches and discoveries which, forty years ago, rendered the cavern famous, to the commencement of the exploration under the auspices of this Association, the southern entrance has been blocked up, the northern alone being used by visitors. The base of the latter is about 189 feet above the level of mean tide, whilst that of the former is about four feet lower.

The following is the succession of deposits, in descending order which the chamber contained:—

1st. Huge blocks of limestone which had manifestly fallen

from the roof, many of them required blasting in order to their removal, and in some instances it was necessary to blast the masses into which they were by this means divided. One of the blocks measured 11 feet long, $5\frac{1}{2}$ feet broad, and $2\frac{1}{2}$ feet thick; hence it contained upwards of 100 cubic feet, and must have weighed fully seven tons. In some cases two or three of them lay one on another and in a few instances were firmly cemented together by a separate cake of stalagmite between each pair; whilst others lay unconformably, with considerable interspaces. Occasionally what appeared to be a boss or dome of stalagmite proved to be a block, or two or three small blocks of limestone, invested on all sides with a stalagmite sheet. Certain masses, lying at some distance from a drop, were without even a trace of stalagmite.

2nd. Between and beneath these limestone blocks there was a layer of mould of an almost black color. It varied from a few inches to upwards of a foot in depth.

3rd. Underneath the black soil came a cake of stalagmite breccia, made up of comparatively small fragments of limestone, so very firmly cemented together with carbonate of lime as occasionally required blasting. It was rarely less, but not unfrequently more, than a foot thick. Everywhere it was firmly attached to the walls, and it occasionally extended completely across the chamber. Not unfrequently, however, the centre of the chamber was altogether destitute of this breccia; in some instances because there is no drip near the apex, in others because it was intercepted by an overlying limestone block.

4th. The breccia is succeeded by the ordinary reddish cave loam, which contained a large number of limestone fragments, varying in dimensions from bits not larger than sixpences to masses but little smaller than those which lay on the surface. They lie at all angles without anything like symmetrical arrangement. In fact the entire deposit is without any approach to stratification—many of the stones are partially encrusted with calcareous matter, and not unfrequently loam, stones, and splinters of bones are cemented by the same substance into a very tough breccia. The presence of a calcareous drip is more or less traceable everywhere. Hitherto the cave earth has been excavated to the depth of four feet only. How far it extends below this, or what may be beneath it, is at present unknown. Where it is not covered with the stalagmitic breccia, the black soil lies immediately on it, but the line of junction is everywhere sharply defined; in no instance do the two commingle.

Since the large masses of limestone occur at all levels in the cave earth, as well as everywhere above it, it is obvious that whatever may be the cause to which their fall is attributable, they cannot be referred to any one and the same period. They fell from time to time throughout the accumulation of the cave earth; they continued to fall whilst the stalagmitic breccia was in process of formation, as well as during the introduction of the black mould, and they are amongst the most recent phenomena which the cavern presents. And even of those which lie on the surface, there is a conclusive evidence that in some cases a considerable length of time must have elapsed between the fall of two blocks, one on the other; an interval sufficiently great for the formation for the cake of stalagmite between them, and which is sometimes full six inches thick. There can be little doubt that some of them fell very recently even when measured by human standards.

It is by no means easy to determine the cause which threw them down. To call in the aid of convulsion seems undesirable, since it would be necessary to do so very frequently. Moreover it may be doubted whether anything short of a violent earthquake would be equal to the effect. Though the roof of the chamber is of very great span and entirely unsupported, and though it presents appearances which are not calculated to inspire confidence, the violent concussions produced by the frequent blastings already mentioned, blastings which not unfrequently throw masses of limestone, weighing upwards of a ton, to a distance of several feet, have never brought down even a splinter.

The fall of the blocks has sometimes been attributed to changes of dimensions in the roof, arising from changes of temperature, but the fact that the cavern temperature is all but constant throughout the year seems fatal to this supposition.

The masses lying on the surface were a sufficient guarantee that the deposits beneath them remained intact. There can be no doubt that they are at once a proof, and the cause of the undisturbed character of the soil they cover. A portion of the cavern so easily accessible as is this chamber would not have been spared by Mr. McEnery but on account of some great difficulty or discouragement; and in fact he states that the fallen masses completely foiled him in his attempts to make explorations in it, excepting in one branch some distance south of the area selected by the committee. Their own characters, moreover, render it absolutely certain that the deposits have never been violated.

The following is the method of exploration which has been observed from the commencement, and which it is believed affords a simple and accurate method of determining the exact position of every object which has been found:—

1st. The black soil lying or accessible between the masses of limestone on the surface was carefully examined and removed.

2nd. The limestone blocks occupying the surface of the deposits were blasted and otherwise broken up, and taken out of the cavern.

3rd. A line, termed the datum line, is stretched horizontally from a fixed point at the entrance to another at the back of the chamber.

4th. Lines, one foot apart, are drawn at right angles to the datum line, and therefore parallel to one another, across the chamber, so as to divide the surface of the deposit into belts termed parallels.

5th. In each parallel the black mould which the limestone masses covered is first examined and removed, and then the stalagmitic breccia, so as to lay bare the surface of the cave earth.

6th. Horizontal lines, a foot apart, are then drawn from side to side, across the vertical face of each section, so as to divide the parallel into four layers or levels, each a foot deep.

Finally each level is divided into lengths, called yards, each three feet long, and measured right and left of the datum line as an axis of abscissa.

In fine, the cave earth is excavated in vertical slices or parallels four feet high, one foot thick and as long as the chamber is broad, where this breadth does not exceed 30 feet; each parallel is taken out in levels one foot high; and each level in horizontal prisms three feet long and a foot square in the section, so that each contains three cubic feet of material.

This material, after being carefully examined *in situ* by candle-light, is taken to the doorway and re-examined by day-light, after which it is at once removed without the cavern. A box is appropriated to each yard exclusively, and in it are placed all the objects of interest which the prism yields. The boxes, each having a label containing the data necessary for defining the situations of its contents, are daily sent to the honorary secretary of the committee, by whom the specimens are at once cleaned and packed in fresh boxes. The labels are numbered and packed with the specimens to which they respectively belong, and a record of the day's work is entered in a diary.

The same method is followed in the examination of the black mould, and also of the stalagmitic breccia, with the single exception that in these cases the parallels are not divided into levels and yards.

With very rare exceptions the cavern has been visited daily by one and frequently by both the superintendents, and monthly reports of progress have been regularly forwarded to Sir Charles Lyell, the chairman of the committee.

* * * * *

In passing below the black mould we first encounter the stalagmitic breccia. This the workmen carefully break into small fragments in order to detect any articles of interest embedded in it. The search, though not very productive, has not been quite fruitless. In the breccia have been found charred wood, marine and land shells, and bones of various animals, none of which perhaps are extinct.

Immediately beneath this cake we enter the red cave loam, and at once find ourselves amongst the relics of several extinct species of animals. The only differences in the four successive levels in which, as already stated, the red loam is taken out, are simply that the first, or uppermost, is the poorest, and the third, perhaps the richest in osseous remains; and that the three lower levels contain a large amount of minutely comminuted bone, of which there are very few instances in the uppermost foot. In other respects the levels are the same. Everywhere the same in the materials which form the staple of the deposit; in the occurrence of pebbles of various kinds of rock, which differ from those in the overlying black mould only in being less numerous; in the presence of bones in the same condition, and representing the same species of animals; and in yielding flint implements of the same types. It will not be necessary, therefore, to describe each level separately or in detail.

The bones found below the stalagmite are heavier than those met with above it. This distinction is so well marked and so constant as to be characteristic. It would be easy to assign them to their respective deposits by their specific weights alone. Most of those from the red loam are but little discolored; indeed, some of them are of a chalk-like whiteness. A few, however, occur here and there which have undergone a considerable amount of discoloration, a consequence probably, and also a proof of a greater degree of exposure before their inhumation. On most of the

latter certain lines and patches of a lighter color not unfrequently present themselves, which may be likened to such as are sometimes left by mosses or lichens on objects on which they have grown.

A large number of the bones, including jaws, teeth, and horns, are scored with teeth-marks, clearly the work of animals of different kinds. Some of the long bones are split longitudinally. Many appear to have been rolled, including most of those which have been gnawed; and in the case of the latter it is tolerably obvious that the rolling was subsequent to the gnawing. Some of those found beneath the large masses of fallen limestone are in a crushed condition, and thus apparently attest the fact that the deposit in which they lay, and on which the blocks fell, was of a compact nature and capable of a firm resistance.

The minutely comminuted bone already spoken of is commonly found converted, with loam and stones, into a firm breccia. Not unfrequently, however, it occupies the hollow cavities of some of the larger bones. With it there sometimes occurs a cream-colored substance, which in a few instances has been met also in the form of small detached lumps, having a low specific gravity. This, as well as at least some of the comminuted bone, has been supposed to be of fœcal origin.

In cleaning the bones it is frequently found to be impossible to remove entirely the earthy matter from them. They are at least partially invested with a thin film which defies the brush and water. On drying, however, this matter commonly scales off, and proves to be a paste or paint, composed of loam and carbonate of lime, the latter probably derived from drip from the roof.

A large portion of the osseous remains occurs in the form of fragments and mere splinters. The identifiable parts are chiefly teeth, which are extremely numerous. Among the animals represented there are certainly the cave bear, the cave lion, the cave hyæna, the fox, horse, probably more than one species, several species of deer, the tichorhine rhinoceros, and the mammoth. Remains of the hyæna are probably the most abundant, after which come those of rhinoceros and horse. The relics of mammoths, both molars and tusks, are those of very young individuals.

It has already been hinted that flint implements occur everywhere in the cave earth mixed up with the remains of extinct mammals. Several of them were found in the presence of, and some of them by the superintendents. Like the bones, they are least

abundant in the uppermost foot, and occur in greatest numbers in the lowest zones. Altogether, and without reckoning doubtful specimens and numerous chips, nearly thirty 'implements' have been dug out. Though the designation of 'flint' is given to all, some of them are probably of chert. Of the flints, properly so called, some are of a dark and others of a light gray color, whilst a third kind are almost white, and have a porcellanous aspect. The chert specimens are of a lightish gray color. With the exception of three, they are all of the kind known as flakes, flat on one side and more or less carinated on the other. Some of these are fragments only, others were found broken in the deposit with the parts lying in contact, whilst others again are perfect. Some of the broken specimens of the white variety show that they are not of this color throughout their entire mass, but have a dark central axis or core. The flakes agree in character with those in the black overlying mould. The excepted three are of chert, and are worked on both sides. They were found in the second, third, and fourth levels, one in each. That from the second foot is about four and three-quarter inches long, and where widest two and a-half broad. At one end it tapers to a point, and narrows to no more than three-quarters of an inch at the other. In outline it is rudely a segment of a curvilinear figure, and is slightly falciform. The inner or concave margin is the cutting edge. Unfortunately the tip of the pointed end was broken off after exhumation. Those from the third and fourth levels are more highly-wrought implements. They are worked to an edge around the entire perimeter. In outline they are rather ovoid than elliptical, being narrower at one end than at the other. That from the third foot measures four and a-half inches in length, and its greatest breadth and thickness are respectively three and a-quarter inches and three-quarters of an inch. That found in the fourth zone—the lowest yet reached—is the most elaborately finished implement of the series. It is lighter in color, and somewhat smaller than the preceding two, its dimensions being three and a-half inches long, two and a-half broad, and three-quarters in thickness.

Without intending at present to enter on the consideration of all the bearings of the entire evidence produced, the Committee feel at liberty to express their conviction that it is totally impossible to doubt either the human origin of the implements, or their inosculation, in undisturbed soil, with the remains of the mammoth, the cave bear, and their extinct contemporaries.

Nor are these the only indications of human existence found in the cave earth. Several small pieces of burnt bone have been met with in the red loam, some of them loose and detached, others of smaller size, and incorporated in the breccia, composed of loam, stones, and comminuted bone.

Mention has been made already of the occurrence, in the cave earth, of rounded stones not derivable from the limestone hill in which the cavern is situated. It seems probable that at least some of them were selected and taken there by man, though it may not be easy, perhaps, to determine, in all cases, for what purpose. But waiving this point, there are two stones which must not be hastily dismissed. The first of them is four and three-quarter inches long, and something less than an inch square in the section. It is a mass of hard purplish gray grit, and is undoubtedly a whetstone or rather a portion of one. It was found in the first level of the cave earth in a small recess or cavity in the northern wall of the chamber, immediately beneath a projecting stratum of limestone *in situ*. In this cavity the stone stood with its longest axis vertical. The superintendents were inclined to the opinion that it had slipped through a hole into the cavity at a comparatively recent date, and they diligently set to work to find the means of the ingress. Here, however, they were completely foiled. There was no hole or passage, vertical or lateral, by which the cavity could have been entered. Not only, as has been said, was there a thick stratum of limestone *in situ* immediately over the recess, but over this again, as well as over the red loam there was a thick compact mass of stalagmitic breccia, consisting of large and small pieces of limestone firmly cemented, and having a height of fully eight feet, the whole of which was removed before the cavity was disclosed or suspected.

The second stone is a rude flattened spheroid, formed from a pebble of coarse, hard, red sandstone, and apparently used for breaking or crushing. Its diameters measure two and three-quarters and one and three-quarter inches. It was found in the second level of the red cave earth, over which lay an enormous block of limestone, but no stalagmite. * * *

THE SUCCESSIVE PALÆOZOIC FLORAS IN EASTERN NORTH AMERICA.

BY J. W. DAWSON, F.R.S.

The Palæozoic formations of eastern North America may be grouped in four great ages, each characterized by a dis-

inct Fauna and Flora, and a corresponding series of physical conditions. These are the Lower Silurian, the Upper Silurian, the Devonian and the Carboniferous, each of which constitutes a great cycle of Palæozoic time. The rocks supposed to be Cambrian are imperfectly known, and have afforded no fossils. The Permian group has not been recognized. 1. The Carboniferous Flora may be arranged in three subordinate groups: (1.) That of the Upper Coal Formation, consisting of a few of the more widely-distributed species of the preceding Middle Coal Formation. (2.) That of the Middle Coal Formation, the head-quarters of the peculiar Carboniferous Flora, and of the productive beds of coal. (3.) That of the Lower Carboniferous Coal Measures, consisting of a few peculiar species, several of which are not found in the overlying parts of the system. These plants have been widely recognized at this period in Eastern America, and a similar group seems to have existed at the same time in Great Britain. The whole Coal Flora in British North America may be estimated at about 150 good species, of which the greater number are common to America and Europe.—2. The Devonian rocks in Eastern America have afforded eighty-one species of land plants, of which only about ten are common to this and the Carboniferous period. They occur principally in the Upper Devonian, but some extend to the bottom of the system. Though fewer in species, the Devonian Flora is not lower in grade than that of the Carboniferous period. The earliest known species were allied to Lycopodiaceæ. The Devonian Flora has been recognized in Pennsylvania, New York, Ohio, Canada, Maine, and New Brunswick. The number of species common to the Devonian of Europe and America is not so great as in the case of the Carboniferous. 3. The Upper Silurian has afforded land plants only in its upper beds, and only at Gaspé, in Lower Canada. The only well-characterized species is *Psilophyton princeps*, which is also one of the most common plants in the Devonian. The first known appearance of land plants in America is thus at the same geological period with their first known appearance in Europe. 4. The Lower Silurian has as yet afforded no land plants. It abounds in objects called fucoids, but the greater part of them are trails of worms, crustaceans, and mollusks, rill-marks, shrinkage-cracks, &c. Those that show carbonaceous matter or structure seem to be allied to modern Algæ. The extent of shallow-water deposits of the Lower Silurian explored in Eastern America without any discovery of land plants, would seem

to afford at least a presumption against their abundance at that period. The author anticipates that the Laurentian will yet afford evidence of at least the existence of Algæ before the Palæozoic period. He has prepared for communication to the Geological Society a detailed account of that part of the above succession which relates to the Carboniferous of British America.

REPORT ON LUMINOUS METEORS.

BY JAMES GLAISHER, F.R.S.

The principal points in this valuable Report were as follows: The number of meteors observed during the past year had been unusually small, partly owing to the cloudy state of the sky, and partly owing to the absence this year of certain acknowledged star-showers, namely, those of January, April, and August. The November shower, although concealed in England by clouds, was observed with considerable interest at Malta. If the sky be clear, the circumstances are altogether favorable for its re-appearance, in the present year and the next, on the morning of the 13th of November. Its greatest display is expected in 1866, but in the present year it is desirable to be prepared for its appearance. The British Association having printed maps for the use of the Committee (specimens of which were presented with the Report), every means will be provided to members willing to take part in the observations of this shower to enable them to record their observations with facility. A remarkable shower of meteors was observed on the 18th of October, coinciding with a date on which fire-balls have made their appearance in more than average numbers. The radiant point of this shower is perfectly well defined in Orion. There was a less conspicuous star-shower on the 28th of July, with a radiant equally distinct close to Fomalhaut, the most southerly star observed on our meridian. A number of other accurate observations of star showers are included in the Report. Of large meteors, the greater number took place in December. Two detonating meteors were also observed: the first in England, on the 20th of November; the second in Scotland, on 21st of February. Observations show that, on the first of these nights, shooting stars were extremely scarce, so that, at Weston-super-Mare and Hawkhurst, only one or two meteors could be counted in an hour. This fact illustrates, in a remarkable manner, the adventitious character of large meteors. A third detonating meteor, on the 30th of April, was doubly observed, at Manchester and Weston-super Mare, and

its height well determined. The nearest approach to the earth was thirty-seven miles. Startling as are the accounts of detonations heard from such a height, it is yet more surprising that the report from such a distance should be brief and momentary. The sounds caused by meteors yet offer much which it is hoped will be explained by further observations. Interesting matter is given in the Report by Mr. Brayley and Mr. Sorby, "On the Origin of Meteorites, and on the Series of Physical Processes of which they are the Result." It appears, from microscopic examinations of their structure, that *aërolites* resemble, in their appearance, certain igneous terrestrial rocks; but characteristic peculiarities in their structure evince that this is far from being a complete account of their previous history. M. Brayley suggests that they originate in gaseous matter projected from the equator of the sun, and condensed to a solid form in its passage through interplanetary space. A gradual condensation from the vaporous state is said, by Mr. Sorby, to represent more nearly than any other the condition under which they must have been consolidated. In this view of the origin of meteorites, their source is considered to be unique, and they are traced to the energetic forces whose modes of action are considered in solar physics. The bodies thus arising are termed "meteoritic masses," to distinguish them emphatically from all other members of the solar system. In a "Memoir on Sporadic Shooting Stars," Mr. Newton, basing his conclusions upon a previous knowledge of their height, arrives at some interesting results regarding the number and distribution of these bodies in space. The average height of the centres of their visible tracks is sixty miles above the earth. Their number in the atmosphere daily is seven and a half millions, and if not intercepted in their flight, there would be found in the space occupied by the earth at any instant in its orbit, 13,000 of such bodies pursuing different orbits. Of shooting stars visible in telescopes, Mr. Newton calculates that the number is at least fifty times greater than the number of those visible to the naked eye. Indeed, there appears to be no limit to their minuteness or to their numbers. Their velocity is greater than that of the earth in its orbit, and Mr. Newton supposes they are grouped together according to some law, probably that of rings encompassing the sun, resembling, in their inclinations and dimensions, the orbits of the comets. Mr. Newton, in conclusion, supposes that these bodies, which he terms meteorites, are not fragments of a former world, but rather materials from

which new worlds are forming. Meteorites and meteoritic masses, then, constitute two classes of bodies which have to be considered in meteoric astronomy. It is, however, reasonable to presume that the same forces which, in the phase of greatest concentration of the solar system, give rise to meteoritic masses might, in a phase of vastly greater antiquity and of greater extension of the solar orb, have given rise in a similar manner to rings of meteoroids. Continued observations directed to the phenomena of shooting stars will certainly remove doubt from this province of astronomy, and probably throw light on some of the most difficult questions in cosmical philosophy, such, for example, as the existence of organic matter (a kind of peat or humus) in the meteorites of Orgueil.

RESEARCHES IN THE LINGULA FLAGS IN SOUTH WALES.

BY MR. H. HICKS AND J. W. SALTER, F.G.S.

Mr. Henry Hicks, a resident of St. David's, having been entrusted with a grant to aid him in searching out the fossils of these strata, the results have been so important, as to lead to the discovery of an entirely new British formation, and the authors propose a new term for the group. The Cathedral City of St. David's was anciently called 'Minevia,' and hence, following the example of the best geologists, viz., first to ascertain the position, then the fossil contents of a group, and then to name it, the authors propose the term 'Minevian,' for the lowest division of the Lingula flag. Mr. Hicks described five sections on the coast north and South of St. David's—the coast affording admirable views of all the beds, from the central syenite through the olive gray, green and purple beds of the Lower Cambrians, in to the light-gray, black and grey shales of the Minevian group. Some of the sections show a passage from this group into the Ffestiniog group of Professor Sedgwick which forms the main mass of the Lingula flags proper, and in Whitesand Bay these are again overlaid by the Skiddaw group and the Llandeilo flags. Each of the sections has shown fossil traces after a long and persevering search. But the section at Porth Raw is not only the typical one, but contains all the principal fossil types—trilobites of six or seven genera, and about 15 species; brachiopod and pteropod shells, cystideæ, sponges of two or three different kinds. All of them are distinct not only as to species, but usually as to genera also from the overlying rocks of the

Lingula flags. And as the history of discovery in the Palæozoic rocks has been that every group beneath the old red sandstone, containing a distinct fauna, has received a separate name, the authors hold it of prime importance not to confound this fauna with any of the overlying rocks of the Silurian or even upper Cambrian systems. If Llandeilo, Caradoc, Llandovey, and Wenlock imply distinct periods of creation, much more does the term Lingula flag, Ffestiniog group indicate a remote period, in which not even the genera of fossil animals common in the great Silurian deposits are to be found. All is distinct and anterior, lower in point of organization, more limited in point of numbers; the species even, with some exceptions, diminishing in size. We seem to be coming to the dawn of animal and vegetable life. As indicative of the value of a close observation of these old faunæ, it may be sufficient to say that by means of this Minevian group, we can tell the exact horizon of the gold-bearing rocks of Wales; we can identify accurately the oldest fossil-bearing strata of Bohemia and Sweden with those of our own country, and assign them their exact position in the Palæozoic series. The genus *Paradoxides* becomes in this way one of the medals of creation, and the index of a most remote age—so remote that only a few, and those the humbler members of the invertebrate classes, inhabited the sea. With regard to the distribution of the fossils themselves, the lowest beds, which actually lie under the uppermost coarse beds of the Cambrian grits, only distinguished from them by the want of purple color, contain a species of *Paradoxides* (*P. Aurora*), with which are associated some minute trilobites; *Agnostus Microdiscus*, &c. Further up we have *Paradoxides* again, but of a distinct species, and larger. The mass of the fossils then come in, both crustacea, shells, and sponges; and high up in the series a third *Paradoxides*, so large as to attract general notice; the well-known *P. Davidis*. Specimens of each of them were exhibited on the reporter's table. Mr. Hicks described beds of contemporaneous trap, and showed their origin and direction, and the faults of the region were touched upon, but could not be fully described.

Mr. J. W. SALTER offered some remarks upon the fossils of the flags. He first gave a general section of the district. The central portion consists of a mass of altered Cambrian rocks, and also a nucleus of syenite. The central part is succeeded by black shales and other deposits. The middle lingula succeeds; and these are capped

with the Llandeilo measures, with the representatives of the stiper stones coming in between. The fossils occur in the lower member of the lingula flags. Thirty-three species are now known from these measures, and, with the exception of two species, have all been discovered by Mr. Hicks. From this cause he proposed to term this group of rocks the Minevian division, a name derived from the ancient designation of St. David's. The largest form of trilobite yet found in Great Britain (sometimes twenty inches in length, and called *Paradoxides*) is characteristic of these beds, and the smallest known trilobite (*Agnostus*) is also peculiar to this formation. With the crustacea occur several forms of mollusca of a low order. A few species of *Cystidea* are found, also several species of sponges. The fauna of St. David's is represented in the neighborhood of Dolgelly. The series is doubtless the equivalent of well known beds in North America, Bohemia, Sweden, and Spain. The result of the recent exploration has been to carry down the lower forms of life only. As we descend, the higher forms of life successively disappear. When we reach the lower beds, only annelids remain.

The PRESIDENT said every geologist must feel infinitely indebted to Mr. Hicks for his discovery, and to Mr. Salter for his lucid explanations. With respect to the general position of these beds, it appeared to him that they formed the natural base of that great system of rocks, the Lower Silurian. In Sweden, in America, in Germany, and all over the world, this primordial zone was the natural base of the Silurian or great Lower Trilobitic system.

Principal DAWSON said it was very pleasant to find so close a parallelism between the Lower Silurian rocks of this country and of Canada and other parts of North America. As Mr. Salter had mentioned, the great *Paradoxides* was found in Newfoundland in rocks of probably the same age as the Lingula flags. The same rocks ran along Nova Scotia, being the gold-bearing rocks of that country, but the *Paradoxides* had not yet been found in them. There was a continuation of the same great zone in Massachusetts; and in Canada, there were the very remarkable rocks constituting the Quebec group, containing similar fossils, and being, as Sir William Logan believed, a deep-sea formation of Lower Silurian age; so that all this brought what was known in America into harmony with what was found in this country. The occurrence of sponges in these rocks had been mentioned by Mr. Salter. The same thing had been ascertained in Canada by Mr. Billings in rocks probably nearly as old.

A FEW NOTES ON THE STRUCTURE OF THE MATTERHORN.

BY E. WHYMPER.

When one observes the great peak of the Matterhorn at a short distance, it is seen that its rocks are separated into three great divisions, of which the middle mass is the largest, and grey in color, while the upper and lower sections are apparently of a dull red. On ascending the mountain, these divisions are so clearly apparent, and the junctions of the sections are so marked, that it is almost possible to see the lines of separation. The rocks on the upper and lower divisions, however, it is found, are by no means uniformly red in color, but are interspersed with others of a green and of an iron grey. It is from the red rocks being so much more positive in tone that they present a uniform tint when seen at a distance. The specimens collected comprise fragments from each of these divisions. Those taken from the summit were detached when collected, but others were broken from the living rock. After exhibiting specimens of the rock, the writer went on to say: The summit of the Matterhorn is a roughly-lined ridge of 350 feet to 400 feet in length. It is extremely precipitous on one side; but on the side which descends towards the glaciers of Zmutt the inclination is moderate, and it can be traversed with great facility. There are several little points on this side, and the highest of them is usually covered by a small cone of snow. The whole of the summit is covered with disintegrated fragments, and the living rock is not anywhere visible. It was observed by De Saussure that the beds of the Matterhorn rise towards the N. E. at an angle of 45° . This is scarcely exact, although correct on the whole. They dip towards the south and west; but the inclination towards the west is three times as great as it is to the south. In consequence of these dips, the plane surface of the beds presents a surface sloping downwards on the western and southern sides of the mountain, and the fractured edges overhang each other. It is mainly from this cause that so much difficulty has been experienced in all previous endeavors to ascend the mountain; and it was from observing this fact that I formed the resolution to attempt the ascent by the north-western face; for although it appeared smooth and unbroken, yet I argued that the fractures would fall in exactly the reverse manner to that which I have described, and this would render the ascent easy, even although the hold they might afford should be but small. The theory was correct, and the whole of the north-eastern face was found to be in, fact, a long staircase, with

the steps shelving inwards. It is also in consequence of these steps that stones do not fall to any distance on the north-eastern side; for it is evident that if any disintegrated fragments do break away, they must sooner or later be arrested on a ledge, and, indeed, I did not see any fall during the two days which I passed on the mountain. On the other side, on the contrary, the Matterhorn rains down showers, nay, torrents and avalanches of stones, both by day and night. Thus these dips become on one side a source of safety, but on all others a source of great danger. We are enabled by a knowledge of these facts to account for the enormous moraine of the Zmutt glacier, which has attracted the attention and the curiosity of all observers; for the Zmutt and its tributary, the Tiefenmatter, sweep round the two faces of the Matterhorn on which we should expect the greatest masses of rock would fall. We find, moreover, that the Furguee glacier, which is below the N. E. face, has scarcely any moraine. The consideration of these facts also suggests naturally that we see nearly the primal form of the Matterhorn on its N. E. side, but that great changes have taken place on the others. We are sure, indeed, of this, for we see the fallen fragments below. We can go a step further. The fallen masses are chiefly of the red rocks, and they must have either come from the upper or the lower of the three divisions. On the side of the Zmutt and the Tiefenmatter glaciers, however, the lower division is almost entirely covered by snow and glaciers. We are forced, therefore, to the conclusion that they came from the upper; and it is doing no violence to the imagination to suppose that at some early period the now isolated obelisk of the Matterhorn was only the termination and the culminating point of the ridge of which the Dent d'Erin and the mountains to the south of it formed also a part.

ENTOMOLOGICAL SOCIETY OF CANADA.

DESCRIPTION OF *ALYPIA LANGTONII*.

BY WM. COUPER, QUEBEC.

The male of the above species* was unknown to me, when I described and figured the female in the February number of this Journal (p. 64). The former is so different in color and markings, that a description is necessary.

The upper surface of the wings is not so dark as in the other

* Exhibited before Quebec Branch, Ent. Soc. of Can., July 5th, 1865.

sex; the color is brown, covered with a beautiful purple gloss. The spots on the anterior wings are in shape and color the same as in the female. There are two white spots on each of the posterior wings, one on the medial cell, opposite the limbus, as in the female, and the other, twice the size of the latter, occupies the sub-dorsal region. This spot is much larger on the under surface extending on the margo interior, and it is the distinctive mark between the sexes. Dorsal part of the body tufted with white hairs. Length $1\frac{3}{10}$ inch.

On the 29th June, I captured both sexes of this species in the Gomin swamp, near Quebec. *Alypia* resembles the *Hesperidae* in flight, but when at rest, they do not erect their wings like the species of the latter family. It is very difficult to capture *Alypia*; three or four specimens may be considered a good day's work.

The following note relating to this species, was received in September last, from Aug. R. Grote, Esq., of New York:—"Your note and specimen of *Alypia Langtonii*, Couper duly handed to me. I thank you very much for the specimen. This species is very closely allied to *Alypia 8-maculata*, with which you should compare it rather than with *A. MacCullochii*, Kirby, to which latter *A. Ridingsii* Grote, is nearer allied. *A. Langtonii* ♀ differs from *A. 8-maculata* ♀ merely by the slightly more prominent palpi, and the presence of but one larger external spot on the secondaries. Kirby's species should be turned up by some of your entomologists. The ♂ of *Alypia 8-maculata* differs from the ♀, principally in that the inner larger spot on the secondaries is extended to internal margin and base of the wing."

CANADIAN INSECT ARCHITECTURE.

BY WILLIAM COUPER, QUEBEC.

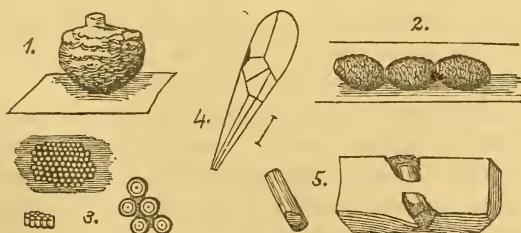


Fig. 1.—I found this pretty specimen on the 11th April. It was attached to the bark of a birch stump in Mr. Montizambert's

woods, near Quebec. It is the work of a solitary hymenopter, probably belonging to the European family EUMENIDÆ, but whether the Canadian insect is the same as 6, fig. 87, vol. ii, of Westwood's Introduction to the Modern Classification of Insects, remains to be determined. The following extract from the above book will suffice to throw some light on this insect architecture :

"Geoffroy (Hist. Ins. Paris, tom. ii, p. 378, pl. 16, fig. 2) has described a species of EUMENES (*V. coarctata* Linn.) which differs somewhat in its habits from the rest of this family. This species constructs upon the stems of plants, especially heath, small spherical nests formed of fine earth. At first a hole is left at the top, through which the parent fills the cell with honey, undergoes the metamorphosis, and makes its escape through a hole which it forms in the side of the cell which contains but a single insect."

Westwood's illustration (7, fig. 87) and the above description corresponds with the Canadian architecture; but, as Mr. Cresson, of Philadelphia, does not include *V. coarctata* in his list of North America EUMENIDÆ in Proceed. Ent. Soc. Philad., vol. i, p. 327, I infer that the insect and its architecture have not been heretofore described as occurring on this side of the Atlantic. I found at Toronto a similar specimen of the work of a solitary wasp, but failed to obtain the insect from it, and I have been equally unfortunate with the one found at Quebec. The insect, not making its appearance up to the middle of June, I made a hole in the side of the nest, with a sharp-pointed instrument, which wounded and destroyed the larva. The inside of the nest is lined with a strong silky substance. Should I hereafter obtain the builder of this form of insect architecture, and recognize it as identical with the one mentioned by Westwood, it will not only sustain the supposition that at one time a land connection existed between Europe and America, but will also be an additional species in evidence of Mr. B. D. Walsh's argument (Proceed. Ent. Soc. Philad., vol. iii, p. 213) against statements of some American naturalists that separate insect creations have occurred on this continent.

I found another beautiful specimen of fig. 1, on the 25th July, attached to a fence on the St. Louis Road, not half a mile from the locality where the figured specimen was discovered. The structure stood out from the fence—indeed, I would have passed it, had not the button-form on the top attracted my notice. Its foundation is different from the figured one; instead of being spherical, the form is dome-shaped, the fence having been the base

of the structure, therefore, its contents were exposed when it was detached from its position. It contained the larva of the hymenopter and two fresh looking caterpillars, which it devoured together with a common fly that I gave it on the following day. The larva is about half an inch long, flesh-colored, smooth and glossy, having about thirteen rings. It has since lined the interior of its nest with a coating of fine white silken threads. It is difficult to explain the use of the button-like form which is always on the top of the nest of this wasp. When I found the nest, it contained two small caterpillars which only served the larva one day, and it afterwards devoured common houseflies. Can it be that the button or top is removed by the parent insect in order to supply its progeny with additional food? When the architecture of this wasp is newly formed, the top has a regular concavity, and the edges are well rounded and sharp, which is the case with the specimen found on the 25th July. The top of specimens found early in spring, and which were exposed during winter, are not so perfect, and after making allowance for exposure to the weather, I am led to think that the parent insect opens the top of the nest to supply the larva with additional food, reconstructing it with less regularity than the original form: the top is evidently the last part of the structure finished. There is no other substance but clay or mud and sand used by the parent insect, and it is not until the larva had finished feeding, and devours the material supplied to it, that it lines the walls of its cell. The economy of this insect is not yet thoroughly investigated. I may have another opportunity of doing so.

Fig. 2.—The three nests above figured were found attached to the bark of a stump in the same locality where the former specimen was found. They belong to a different genus, and the architecture corresponds with that of the genus *Osmia*, an European mason-bee, the cells of which are figured in Rennie's *Insect Architecture*, p. 41, fig. 2. The nests of this insect are made of clay and sand, but they are smaller than those of *Osmia bicornis* of Europe. There are three series of cells illustrated in this work, two of which produced the last-named insect, and from the third came *Megachile muraria*, and a dipterous parasite. The author is evidently at fault, as the similarity of structure represented by the illustrations are alone sufficient to show the work of one species. *M. muraria* Linn., is a sand-burrowing bee, and I am not aware that it is a parasite on

any species of its own family. The Quebec cells had no winter protection; they were found in a position exposed to a low temperature during winter. I have not detected either of these species constructing their nests, and whether they are filled with honey, pollen, insects on their larvæ, as stated by Westwood, p. 241, I cannot state positively, but I am led to believe that the interior of fig. 1 is filled either with honey or pollen by the parent insect. Neither of the cells, fig. 2, produced an insect. Probably the low temperature destroyed the larva.

Fig. 3 illustrates a mass of what, at first I took to be the cocoons of a species of microgaster similar to 17, fig. 76, Westwood's Int. to Mod. Class. of Ins., vol. ii. They were found attached to a paling on St. Foy's road by Mr. Geo. J. Bowles, of Quebec. I have since discovered that they are the eggs of a species of geometer, probably the canker-worm figured in Harris's Insects Injurious to Vegetation, p. 463.

Fig. 4 is the anterior right wing of a hymenopter, belonging to the family Crabonidæ, the genus and species of which are unknown to me. The insect is completely black. Head wide; eyes reniform; antennæ inserted in front, thickened at their tips; face above the mandibles silvery; wings iridescent, anterior wings composed of eight, posterior, of seven cells; posterior legs about twice the length of anterior; length from the base of antennæ to tip of abdomen five-twentieths of an inch.

Fig. 5 represents the piece of a maple stump containing the cell of the last described solitary wasp. It appears to be allied to that of fig. 2 in its mode of mason-work. Instead of forming an exposed oval cell made entirely of clay and sand, the parent insect selected an old coleopterous larva hole which runs obliquely upwards in the stump, and the cell of the hymenopter is near its exterior, as seen in the figure, about seven-twentieths of an inch long, having an interior as well as an exterior barrier of clay, represented by the dots in the wood-cut. The intervening space is occupied by an oblong thin cocoon, similar to a quill membrane. One species, the *Trypoxylon figulus* of Europe, makes use of the holes of other insects commenced in woodwork, by first enlarging and then plastering them with a covering of fine sand; and I have noticed that when the American mason-wasp finds a suitable hole terminating at a short distance from the entrance, that the clay used by it is what closes the mouth of the cell, one of the wasps keeping guard while the other is away procuring material for the work.

I am indebted to my fellow-laborer in entomology, Mr. Geo. Jno. Bowles, for the illustrations accompanying this paper.

Read before the, Quebec Branch, 7th Sept., 1865.

OBITUARY NOTICES.

SIR W. J. HOOKER.

The brief announcement in our last number of the death of Sir William Hooker will have been perused with feelings of regret by all our readers, and by a very large circle with the deepest personal sorrow. During his long career he had succeeded in attaching to himself the affectionate regard of a long series of friends, pupils and correspondents; and there is no corner of the earth where his loss will not be mourned with heartfelt grief, by some one to whom his uniform kindness lent a helping hand. For more than fifty years he has occupied a distinguished place as a man of science; and throughout that long period, first as a successful teacher, and later as the head of our great national establishment, with the rise and progress of which he is identified, he has been conspicuous for his singleness of purpose, his forgetfulness of self, his zeal in the discharge of his duties, his sagacity in forming plans, and the success with which he carried them out. The death of such a man is no common loss to the world, and we have therefore spared no pains in getting together authentic particulars of his life.

Sir W. J. Hooker was born in 1785; his father, who was in business at Norwich, being a man who devoted all his leisure to reading, especially travels and German literature, and to the cultivation of curious plants, by which, doubtless, was laid the foundation of that love of Natural History for which his son was so distinguished. Sir William's education was received at the High School of Norwich. Having at an early age inherited an ample competency from his godfather, William Jackson, Esq., he formed the design of devoting his life to travelling and natural history. Ornithology and entomology first attracted his attention; but, being happily the discoverer of a rare moss, which he took to Sir J. E. Smith, he received from that eminent botanist the bias which determined his future career. Henceforth, botany was his sole aim; and with the view of collecting plants, he made expedi-

tions to Scotland and its islands, France, Switzerland and Iceland, and made extensive preparations for a prolonged exploration of Ceylon, which plan was, however, frustrated by the disturbances which broke out in that island.

During this period, 1806—14, he formed the acquaintance of all the principal scientific men in England and on the Continent, and commenced that intercourse and correspondence which never ceased till the day of his death. In 1815 he married the daughter of Dawson Turner, of Yarmouth, himself well known as a good botanist, and settled at Halesworth, in Suffolk. Here was laid the foundation of his now magnificent herbarium, and here commenced a long series of valuable botanical works, which followed each other at short intervals up to the present time. An increasing family and a decreasing income induced him, in 1820, to accept the Regius Professorship of Botany in Glasgow, at which place the next twenty years of his life were passed, and where his popularity as a lecturer, his admirable method of training his students, and his genial and attractive manners, soon made his house a rendezvous for all scientific men who visited Scotland—we might almost say England. Gradually his correspondence and his herbarium alike increased; the latter receiving large contributions from his numerous pupils, who, in foreign countries, remembered with gratitude the teacher who had placed science before them in so attractive a form.

In 1836 he received the honor of knighthood from William the Fourth, in acknowledgment of his distinguished botanical career, and the services he had rendered to science; and in 1841 his connexion with Scotland terminated, and a new era of his life began with his appointment to Kew. To be Director of Kew Gardens had long been the ambition of Sir William Hooker's mind; and throughout his long residence in Glasgow he never abandoned the possibility of eventually being placed in that position. He was encouraged in these views by a nobleman well known for his distinguished patronage of literature and science, and himself a keen horticulturist and no mean botanist. We allude to the late John, Duke of Bedford, who, through the influence of his son, Lord John Russell, a statesman then rapidly rising into power, exerted a silent but most powerful influence with the Government and officers of the Queen's Household, in effecting the transference of the Gardens to the public. Sir William's appointment was indeed drawn up by Earl Russell; it gave him a salary of £300

a year, with £200 to hire a dwelling-house for himself, which should be large enough to contain his library and herbarium, the latter requiring no fewer than twelve ordinary sized rooms for their accommodation. This was afterwards increased to £800 a year, with an official house in the Gardens, and accommodation for his herbarium in the residence of the late King of Hanover, where it forms the principal part of the great Herbarium of Kew. The noble Earl is fond of stating that on taking Sir William's appointment for signature to a brother Lord of the Treasury, the latter remarked, "Well, we have done a job at last!"

The history of his career as Director of the Royal Gardens is so well and so widely known, that it need not detain us long. From a garden of eleven acres, without herbarium, library, or museum, and characterized by the stinginess of its administration, under his sole management it has risen to an establishment comprising 270 acres, laid out with wonderful skill and judgment;—including an arboretum of all such trees and shrubs as will stand the open air in this country, magnificent ranges of hot-houses and conservatories, such as no three establishments on the Continent put together can rival;—three museums, each an original conception of itself, containing many thousand square feet of glass, and filled with objects of interest in the vegetable kingdom from all parts of the globe, a herbarium unrivalled for extent, arrangement, accuracy of nomenclature, and beauty of keep, and excellent botanical libraries, including small ones for the use of the gardeners and museums.

To the accumulation of these treasures he not only brought all the powers of his Glasgow correspondence, but by means of his friendly relations with the Admiralty, Colonial and Foreign Offices, India Office, and many private companies, not only enlarged the bounds of his intercourse in all directions, but at a comparatively trifling cost procured specimens from countries the most distant and difficult of access.

To him is due the formation of many of our colonial Gardens, and the resuscitation of the rest; his example has stimulated national gardens on the Continent to a degree they never felt before; whilst the amount of information on all branches of economic botany which he has diffused among the laboring and manufacturing classes can hardly be over-estimated.

In conclusion, it is only right to state, that though these more public duties have naturally attracted the most attention, his scientific labors not only did not cease on his coming to Kew,

but were literally doubled. Rising early and going to bed late, and rarely going into society, the whole of his mornings and evenings were devoted to scientific botany. The species *Filicum*, prepared wholly at Kew, is of itself a sufficient monument of one man's industry; and when to this we add that he published from his own pen upwards of fifty volumes of descriptive botany, all of them of merit and standard authority, it must be confessed that his public career has in no way interfered with his scientific one. Indeed, up to the day of his death his publications were progressing as busily as ever, and the first part had appeared of a new work, the '*Synopsis Filicum*,' for the continuation of which extensive preparations had been made.

Not content with publishing himself, he was always forward in obtaining for others remunerative botanical employment. Besides numberless appointments given to young and rising gardeners and botanists, he procured the publication of the results of many scientific expeditions and missions, and latterly, after many years' strenuous exertion, he induced almost all our Indian and Colonial Governments to employ botanists upon the publication of their Floras.

In person Sir William Hooker was tall and good-looking, with a peculiarly erect and agile gait, which he retained to the end of his life. His address and bearing were singularly genial and urbane, and he was as remarkable for the liberality and uprightness of his disposition, as for the simplicity of his manners and the attractive style of his conversation.

He died at Kew, of a disease of the throat, then epidemic at that place, on the 12th of August, having just completed his eightieth year. His widow survives him, a lady whose varied accomplishments were of invaluable assistance to him in his scientific labors throughout his married life; and he leaves one son, the present Assistant-Director of the Royal Gardens, and two married daughters.—*London Athenæum*.

DR. LINDLEY.

Science has just sustained a heavy loss by the death of Dr. John Lindley, one of the most hard-working and celebrated botanists England has ever produced. Dr. Lindley was born at Catton, Norfolk, in 1799, and at an early age turned his attention to the study of the Vegetable Kingdom. When he first entered scientific life, botany was just emancipating itself from the deadening influence of the artificial system, in this country upheld by a

narrow-minded party. Whoever ventured to write or say anything against these sages was at once a marked man. The treatment which Dr. Gray received for daring to publish the first British Flora, arranged according to the Natural system, is no isolated case. Dr. Lindley's history, and that of several other men of genius, furnish additional examples. * * * * Dr. Lindley's rise, in the estimation of his contemporaries, was rapid, and for more than thirty years he was the centre to which botanists turned for advice and help, and around which botanical science in this country moved; Robert Brown, his equal—or let us rather say superior—in intellectual grasp, being of too retiring a disposition to serve that purpose.

Dr. Lindley's external history is briefly told. He was for many years Secretary to, not to say the life and soul of, the Horticultural Society during its palmiest days, when botanical collectors such as Douglas and Hartweg were sent out to remote parts of the world, when Knight and Sabine published the result of their investigations, and new methods of cultivation were practically and successfully demonstrated at Chiswick. To his connexion with this body of enlightened men is owing his conception of his 'Theory of Horticulture,' a work which has done more to put gardening on its proper footing than any other, and which in this country went through several editions, and has been translated into many European languages by men of real eminence. This same connection also led him to feel acutely the want of a good weekly gardening newspaper, such as Fred. Otto had established in Berlin some years previously, and the 'Gardener's Chronicle' was the result. Dr. Lindley became the editor of the paper, and held that office till the day of his death. It offered him a ready field for expressing his opinions, freely criticising all that was unsound and shallow, and holding out that helping hand to rising talent so shamefully withheld from him on his first entry into scientific life. The 'Botanical Register' offered another opportunity of advancing his favorite science, by figuring and describing the most remarkable new plants that came to this country. Many of our garden pets, the names of which have become household words, such as Fuchsias, Verbenas, and Calceolarias, were first made known in the pages of that periodical. Dr. Lindley's particular favorites, however, were none of the plants just mentioned, but those most singular of all vegetable forms the Orchids; and it may be said that he brought them into fashion. For many years he labored incessantly

santly to describe their numerous representatives, and interpret their singular structure. It took him ten years to work out 'The Genera and Species of Orchidaceous Plants,' and another ten years to complete various memoirs on these plants, which he published under the name of 'Folia Orchidacea.'

The writings of Dr. Lindley form quite a library by themselves. There are amongst them both elementary books, and works intended merely for leading men of science. His 'Fossil Flora of Great Britain' has endeared him to geologists, and his various works on gardening to horticulturists. Perhaps the most widely known of all his works is 'The Vegetable Kingdom,' which appeared in 1846, and gives a condensed account of the structure, geographical distribution and uses of plants, arranged according to the Natural system as understood by him. It was an amplification of his earlier attempts in the same direction, and has been found extremely useful. Notwithstanding that its general arrangement of the Natural Orders has never been followed by any botanist, it would be difficult to name a work which has more advanced the cause Dr. Lindley had so much at heart, than this book. When it first appeared, it was stereotyped, and the new editions are merely the old matter with some cancels and supplementary pages. "I can do nothing more with it," we heard him say a few years ago; "I am getting too old to be able to sit up half of the nights as I used to do formerly; and I must leave it to younger men to finish what I have begun." He was right; he was no longer able to sit up half the night deeply engaged in study. As it was, he had worked too hard, and overstrained his brain. His memory, which had always been most retentive, began to fail; and he suddenly found that he must give up all mental labor at least for a time. There was a slight improvement after he had enjoyed some months of undisturbed rest, but it soon became painfully evident to all that the strength of this mental giant was broken, that Lindley had laid down his powerful pen, never to take it up again. He had to give up his connection with the Horticultural Society altogether, and resign the Professorship of Botany at University College, which he had filled for many years. He died of apoplexy on Wednesday, the 1st inst., at his residence on Acton Green, deeply regretted by a large circle of friends.

Dr. Lindley was a member of most scientific societies in all parts of the world, and his name is held dear wherever science is cultivated and true genius appreciated.—*London Athenæum*.

REVIEWS.

ILLUSTRATED CATALOGUE OF THE MUSEUM OF COMPARATIVE ZOÖLOGY, AT HARVARD COLLEGE. NO. 1. OPHIURIDÆ, &C. By Theodore Lyman.

To a working naturalist, no publication is more acceptable than an illustrated descriptive catalogue of an extensive collection ; and no work requires more care and patient application. Good museum catalogues, owing to the labor and expense they involve, are of rare occurrence ; and the thanks of all naturalists are due to the director of the Cambridge Museum, Professor Agassiz, for this excellent beginning of a work which it is to be hoped will be continued in many successive numbers. The work of this catalogue is exceedingly well done, both in regard to scientific accuracy and mechanical and artistic execution. We could have wished, however, that the authors' names had not been changed in cases where a species is referred to a new genus. This not only deprives the original describer of due credit, but interferes with the facility of reference. The difficulty would be better met by giving the original author of the specific name with the letters Sp. following. In the present work the mode followed causes a large number of old familiar species to be referred to the author of this catalogue, who has merely changed the genus. In making this remark, however, we do not wish in the least to detract from the merits of this very excellent catalogue, or more properly descriptive monograph. The objects sought to be attained by its publication are thus stated by Prof. Agassiz :—

“ The publication of the Illustrated Catalogue of the Museum of Comparative Zoölogy has been undertaken with a threefold object. In the first place, like the catalogues of most institutions of a similar character, it is intended to make the contents of our Museum generally known, and to facilitate our exchanges. In the second place, to be the medium of publication of the novelties received at the Museum, which require to be described and illustrated by diagrams or wood-cuts, or more elaborate plates. Finally, it is hoped that it may be the basis of a systematic revision of such natural groups of the animal kingdom as are most fully represented in our collections, and that it may, as far as possible, present to the scientific world the results of the investigations

carried on in the Museum with a view of ascertaining the natural limits of the Faunæ at the present time and in past ages, and the genetic relations which may exist between the order of succession of organized beings upon the earth, their mode of growth, and their metamorphoses during their embryonic life, and the plan and complication of their structure in their adult condition.

“The means for publishing this work have been most liberally granted by the Legislature, at a time when, in a less enlightened assembly, the material cares of the community would have engaged their exclusive attention.”

J. W. D.

EMBRYOLOGY OF THE STARFISH. By Alexander Agassiz.

SEASIDE STUDIES IN NATURAL HISTORY. By Elizabeth C. and A. Agassiz.

These are new products of the teeming workshop of Zoology established under Professor Agassiz at Cambridge. While the great zoologist is himself exploring in Brazil, these works have been issued by his son and by Mrs. Agassiz. The first mentioned is an elaborate account of the remarkable changes through which two of our commonest American star fishes, *Asteracanthion pallidus* Ag., and *A. berylinus* Ag., pass in their progress to maturity. In some respects it forms a supplement to the investigations of Muller and other European naturalists on the Embryology of Echinoderms; but it elucidates several points which had been left in obscurity; and it fully vindicates the claim of the echinoderms to be placed in the great Cuvierian group of radiates, in opposition to the preposterous attempt to place them with the worms, which has lately gained currency in some quarters. Every one interested in these questions should carefully study this work, which will constitute a part of the forthcoming volume fifth of Agassiz's “contributions.”

The second work above named is a popular sea side book, giving an excellent and very interesting summary of the marine radiates of Massachusetts Bay. Most of the species referred to are found also on the shore of Maine and in the Gulf of St. Lawrence, so that the work will form a good companion and guide for visitors to those coasts as well as to Massachusetts. The book is well illustrated, and is at once thoroughly popular and accurate in a scientific point of view.

J. W. D.

MISCELLANEOUS.

PRESERVATION OF STARFISHES WITH NATURAL COLORS; by A. E. VERRILL.—Starfishes may be dried, so as to retain their natural colors almost unimpaired, by immersing them in alcohol of moderate strength for about a minute, or just long enough to destroy the life, and produce contraction of the tissues, and afterward drying them rapidly by artificial heat. The drying is best effected by placing them upon an open cloth stretched tightly upon a frame and supported a few feet above a stove. Care should be taken not to raise the heat too high, as the green shades change to red at a temperature near that of boiling water. By this process I have succeeded in preserving the delicate shades of red, purple and orange of the species found on the coast of New England, including *Solaster papposus*, *S. endeca*, *Cribella*, *Asteracanthion pallida*, *A. littoralis*, and various other species, specimens of which are in the Museum of Yale College. The same process is equally applicable to Echini and Crustacea.—*Silliman's Journal*.

HARVARD UNIVERSITY HERBARIUM.—This establishment is noticed in the Annual Report of the President of the University to the Board of Overseers, made in January last, as follows:—

“Dr. Asa Gray has presented to the University his invaluable Herbarium and his Botanical Library; which have been safely transferred to the fire-proof building furnished, at a cost of over twelve thousand dollars, by the generosity of Nathaniel Thayer, Esq., of Boston. A fund has also been raised by subscription, for the support and increase of the collection.....The gift of Dr. Gray cannot be estimated in money, but it embraces the results of many years' labor faithfully given by that distinguished botanist, aided by the generosity of his collaborators and correspondents in various parts of the world.”

The collections were formally presented by the following letter:—

Botanic Garden, Cambridge, November 30, 1864.

“To Rev. Dr. HILL, President of Harvard University,

“*My Dear Sir*:—I have the pleasure to inform you that the Herbarium and Botanical Library, which a year ago I offered to present to the University, are now safely deposited in the building

erected for their reception by Mr. Thayer. I have regarded them as belonging to the University from the beginning of the present year; but I wish more formally to make them over to the President and Fellows, as the foundation of the Harvard University Herbarium.

"The Herbarium is estimated to contain at least 200,000 specimens, and is constantly increasing. From the very large number of typical specimens it comprises, its safe preservation is very important.

"The Library, from the rough catalogue which has been made out, contains about 2200 botanical works—perhaps 1600 volumes, and nearly as many separate memoirs, tracts, &c.

"The current expenses of the establishment for the first half of the year now drawing to a close have been defrayed by Dr. Jacob Bigelow, who placed in my hands a special donation of two hundred dollars for this purpose.

"I had stated that the income of a capital sum of \$10,000 would be required to defray the current expenses of the Herbarium, *i. e.*, for the purchase of certain collections and books not obtainable by exchange, for freights and charges, paper, alcohol, fuel, &c. I am informed that this sum, which Mr. George B. Emerson undertook to raise by subscription, is substantially secured. It is desirable, but probably not at this time practicable, that this endowment should be so far extended as to provide for the services of a Curator, so that I could myself devote valuable time to the prosecution of important botanical works for which I am prepared, and to which I am pledged.

"I have the honor to be, with great respect, very truly yours,
ASA GRAY."

I N D E X .

	PAGE
Allen, H.—Monogram of the Bats of N. A.....	144
<i>Alypia Langtonii</i>	64, 460
<i>Amara pygmaea</i>	60
<i>Anarrhicas lupus</i>	133
Annelids in the Trenton Limestone.....	314
Annulata in the Post-Pliocene.....	88
<i>Apium graveolens</i>	38
<i>Aspidium fragrans</i>	240, 402
<i>Asplenium viride</i>	240, 400
<i>Athous affinis</i>	61
<i>Attacus Polyphemus</i>	239
Agassiz, Mrs. and Alex.—Embryology of Starfish, &c.....	472
 Bailey, L. W.—On the Geology of New Brunswick.....	 232, 314
Bats—Allen's Monogram of North American.....	144
Beatricea—Billings on the Genus.....	405
Billings, E.—On Silurian and Devonian Fossils.....	184, 405
“ —Palæozoic Fossils.....	424
Blood-root—Dr. Gibb on.....	432
<i>Boletobius bimaculatus</i>	61
Bond, George P.—Obituary Notice of.....	137
Brachiopoda in the Post-Pliocene.....	87
“ —List of, in the Trenton Limestone.....	313
<i>Brassica campestris</i>	40
<i>Brassica oleracea</i>	38
British Association—See contents page.....	iv
Bryozoa—List of, in the Trenton Limestone.....	313
<i>Buccinum</i> —Northern species of, described.....	364
Buccinums—A review of the Northern... ..	364
Book Notices and Reviews—See contents page.....	iv
 Cabbage—On the Origin of.....	 38
<i>Calapoecia</i> , (species of, described).....	425

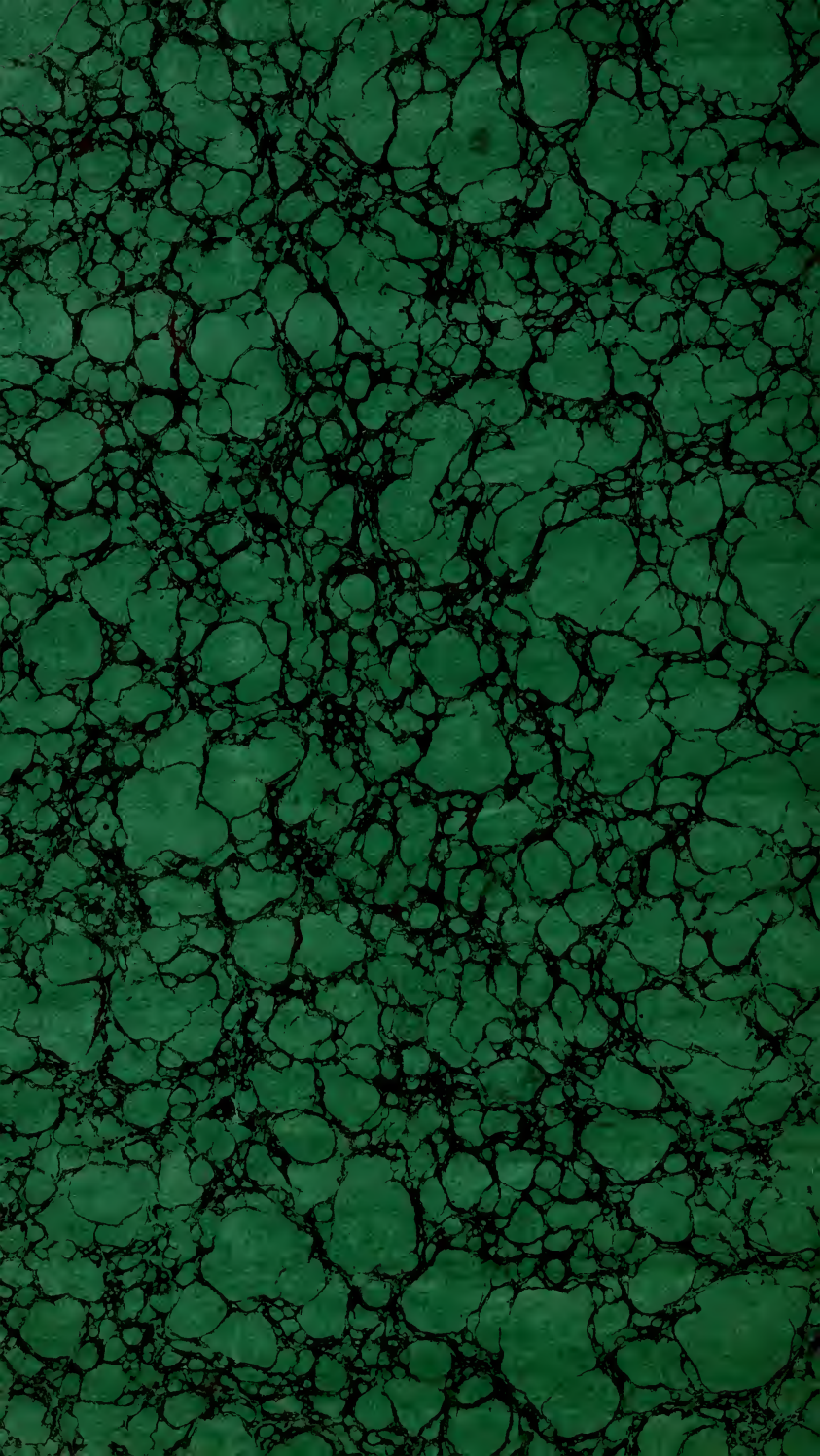
	PAGE
Canada—Geographical Sketch of.....	356
“ —Catalogue of the Cryptogams of.....	390
Carpenter on the affinities of <i>Eozoön Canadense</i>	111
Celery—On the Origin of.. ..	38
Cephalopoda—List of, in the Trenton Limestone.....	314
Cheadle, Dr.—Across the Rocky Mountains.....	65
Chemistry of Natural Waters, by Dr. Hunt.....	1, 161, 296
<i>Chonophyllum Belli</i>	431
<i>Cochlearia Armoracea</i>	41
Coleoptera—Couper on new Species of.....	60
Copper—Macfarlane on the extraction of.....	219, 241
Coultas, Hartland—On Kitchen-Garden Plants	33
Couper, William—On Canadian Coleoptera.....	60
“ —On <i>Alypia Langtonii</i>	64, 460
“ —On Insect Architecture.....	461
<i>Cottus Groenlandicus</i>	128
Crinoidæ—List of, in the Trenton Limestone.....	312
Crustacea in the Post-Pliocene.....	88
“ —List of, in the Trenton Limestone.....	314
<i>Cryptacanthodes maculatus</i>	129
Cryptogams—A Catalogue of Canadian.....	390
<i>Ctenolabrus burgall</i>	134
Cystidæ—List of, in the Trenton Limestone.....	312
<i>Cystiphyllum</i> ———, figured.....	405
<i>Cystopteris bulbifera</i> , McCord on.....	73
Dawson, Dr. J. W.—Plants exhibited by.....	74
“ —Address by.....	75
“ —On <i>Eozoön Canadense</i>	99, 127
“ —On Post-Pliocene Deposits.....	81
“ —British Association.....	409
Devonian Fossils—Billings on.....	184
Drift Phenomena of Labrador.....	441
Drummond, A. T.—Catalogue of Plants by.....	79
Eaton, Daniel C.—On the Genus <i>Woodsia</i>	89
<i>Echinus granularis</i>	86
<i>Edrioaster Bigsbyi</i>	313
Entomological Society of Canada—See contents page.....	iv
Entomostraca in the Trenton Limestone.....	314
<i>Eozoön Canadense</i> figured and described.....	99, 120
<i>Eridophyllum Vennori</i>	431
Falconer, Henry—Obituary Notice of.....	137
<i>Favosites prolificus</i>	420
Ferns—Noticed and Catalogued.....	73, 240, 398

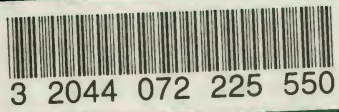
	PAGE
Fishes —J. M. Jones on Nova Scotian.....	128
“ —Of the Gulf of St. Lawrence.....	244
<i>Fistularia</i> ——? Noticed and described.....	134
Foraminifera—List of, in the Post-Pliocene.....	86
Fossils—Billings on Silurian and Devonian.....	184, 405
Fossil Insects found in the Devonian.....	234
Fossils—Lists of, in the Post-Pliocene.....	86
“ “ Trenton Limestone.....	312
Fowler, R. J.—Paper read by.....	75
Fungi—A Catalogue of Canadian.....	390
Gasteropoda in the Post-Pliocene.....	87
“ “ Trenton Limestone.....	313
Geographical Sketch of Canada.....	356
Geological Survey of Canada—Hall on Graptolites.....	42
Geology of the Neighborhood of Rossie.....	267
Gibb, Dr.—On <i>Sanguinaria Canadensis</i>	432
Gill, Theodore—Fishes of the Gulf of St. Lawrence.....	244
Gilliss Capt.—Obituary Notice of.....	135
Glacial Action—Sir R. J. Murchison on.....	21
Glaisher, James,—On Luminous Meteors.....	454
Gold Mining in Nova Scotia.....	197
Graptolites—Prof. Hall on.....	42
Grisebach, Dr.—Flora of the British West Indies.....	150
<i>Grypoidius vittatus</i>	63
<i>Gunnellus vulgaris</i>	133
<i>Gyrinus fraternus</i>	60
Gray, Asa—Letter from, quoted.....	474
Hall, Prof. James—On Graptolites.....	42
Hartt, C. F.—Fossil Insects in the Devonian, discovered by.....	234
“ —On the Fauna of the Primordial Period.....	318
Hepatics—A Catalogue of Canadian.....	395
<i>Heliolites</i> , (species of, described).....	426
Heron—H. G. Vennor on the.....	53
Hicks, H.—On the Lingula Flags.....	556
Hind, H. Y.—On the Geology of New Brunswick.....	232, 314
Hooker, Sir Wm.—Obituary Notice of.....	465
Horseradish—On the origin of the.....	41
Hunt, T. Sterry—Chemistry of Natural Waters.....	1, 161, 276
“ —Geographical Sketch of Canada.....	356
“ —On the Mineralogy of Eozoon Canadense.....	120
Harvard University—Herbarium of.....	473
Icebergs—Sir Roderick Murchison on the Modifying Power of.....	21
Insects found in the Devonian Formation.....	234
Jones, J. M.—On Nova Scotian Fishes.....	128

Kitchen-Garden Plants—Coultas on the Origin of.....	33
Labrador—Packard on Drift Phenomena in.....	441
Lamellibranchiata in the Post-Pliocene.....	87
“ “ Trenton Limestone.....	313
Laurentian Fossils—Sir William Logan and others on.....	92
Lichens—A Catalogue of Canadian.....	392
Lingula Flags—Hicks and Salter on.....	456
Logan, Sir William—On Laurentian Fossils..	92
<i>Lophius piscatorius</i>	133
Lyman, Theodore—Illustrated catalogue by.....	471
Macoun, J.—Catalogue of Plants by.....	79, 350
Matterhorn—Whympcr on the Structure of the.....	459
McCord, D. R.—Paper read by.....	73
McFarlane, Thomas—On Extracting Copper.....	219, 241
“ —Geology of Rossie.....	267
Meteors—Glaisher on Luminous..	454
<i>Microphopala interrupta</i>	63
Milton, Viscount—Across the Rocky Mountains.....	65
Mosses—A Catalogue of Canadian.....	395
Murchison, Sir Roderick—On Glacial Action.....	21
“ “ —Address to British Association.....	347
<i>Mycetochares bicolor</i>	62
<i>Myosurus minimus</i>	240
Natural History Society—See contents page.....	iv
<i>Neckera Macounii</i> Sulliv.....	79
New Brunswick—On the Geology of.....	232, 314
Nova Scotia—Perley on the Gold Mines of.....	198
“ —Jones on the Fishes of.....	128
Obituary Notices—See contents page.....	iv
Packard, Dr.—On Drift Phenomena in Labrador.....	441
Palæozoic Floras in North America.....	452
“ Fossils—Billings on.....	425
Parsley—On the Origin of.....	38
Parsnip—On the Origin of the.....	36
Pasceolus—Billings on Genus.....	195
<i>Pastinaca sativa</i>	36
<i>Perca flavescens</i>	128
Perley, H. F.—On Gold Mining in Nova Scotia.....	198
<i>Petraia</i> , (species of, described).....	429
<i>Petroselinum sativum</i>	38
Phillips, Dr.—Address before British Association..	321
Plants—Catalogues of, presented to the N. H. S.....	79

	PAGE
<i>Podabrus simplex</i>	62
<i>Polydrosus? elegans</i>	63
Polyzoa, in the Post-Pliocene	86
Porifera, in the Post-Pliocene.....	87
Portland Nat. Hist. Society—Proceedings of.....	70
Post-Pliocene Deposits—Dr Dawson on.....	81
Potato—On the Origin of the.....	34
Pteropoda, in the Trenton Limestone.....	313
Quebec Group—Prof. Hall on the Graptolites of the.....	42
Receptaculites—Billings on the Genus.....	184
Rocky Mountains—Dr. Cheadle's Narrative.....	65
Rossie—Sketch of the Geology of.....	267
Rumford, Count—His Researches on Heat.....	152
Salter, J. W.—On the Lingula Flags.....	456
<i>Sanguinaria Canadensis</i>	432
Scudder, S. H.—On Fossil Insects found in the Devonian.....	234
<i>Scomber vernalis</i>	130
<i>Sebastes Norvegicus</i>	129
Shells in the Post-Pliocene Deposit.....	81
Silkworm—A New American.....	239
Silurian Fossils—Billings on	184
<i>Solanum tuberosum</i>	34
<i>Stenopora bulbosa</i>	429
Stimpson, Dr.—Review of the Northern Buccinums.....	364
Sullivant, Dr.—Icones Muscorum of.....	72
<i>Surnia ulula</i>	53
Starfish—Agassiz on	472
“ —Verrill on the preservation of.....	473
<i>Telephorus armiger</i>	62
Thomas, Dr.—Catalogue of Plants by.....	79, 240
<i>Thynnus vulgaris</i>	132
Turnip—On the Origin of the.....	40
Vennor, H. G.—On the Night-Heron.....	53
Verrill, A. E.—How to preserve Starfish	473
Waters, Natural—Dr. Hunt on the Chemistry of.....	1, 161, 276
Whiteaves, J. F.—On the Fossils of the Trenton Limestone.....	312
Woodsia—Eaton on the Genus.....	89
<i>Woodsia glabella</i>	90, 401
<i>Woodsia (hyperborea) alpina</i>	90, 401
<i>Woodsia Ilvensis</i>	90, 400
<i>Woodsia obtusa</i> Torrey.....	92

	PAGE
<i>Woodsia Oregana</i> Eaton.....	90
<i>Woodsia scopulina</i> Eaton.....	91
Whymper, E.—On the Matterhorn.....	459
<i>Xiphias gladius</i>	132
Youman on Force.....	153
<i>Zaphrentis</i> , (species of, described).....	430
Zoophyta—List of, found in Trenton Limestone.....	312





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